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Thirteenth Annual Meeting

MARCH 23, 24, 25, 1953

Shoreham Hotel, Washington, D. C.

SURVEYING AND MAPPING

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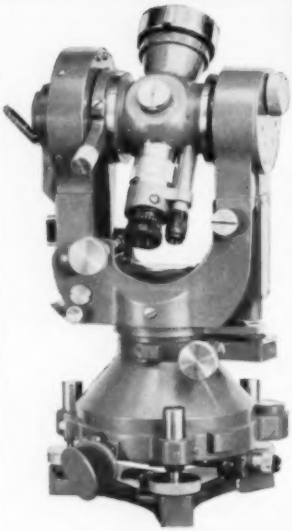

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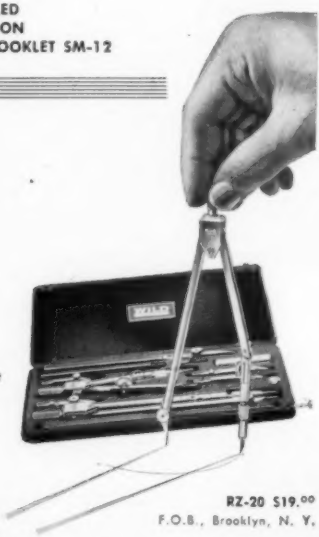

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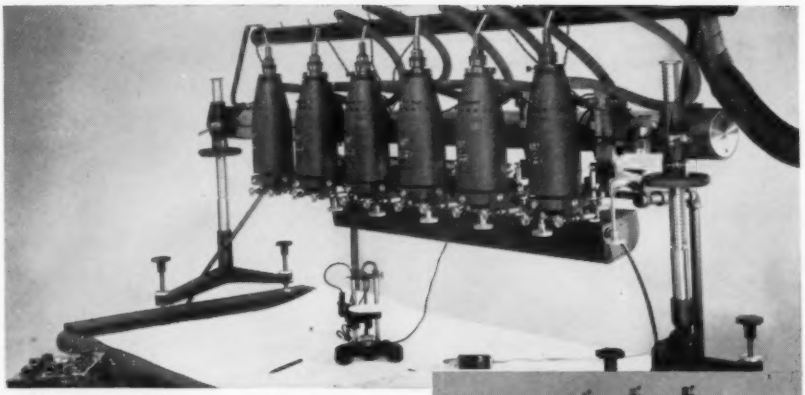

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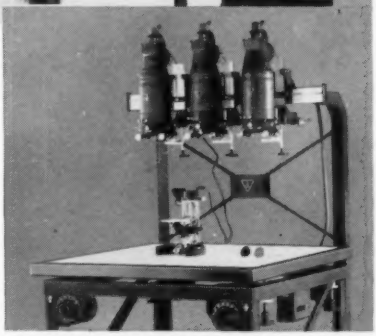

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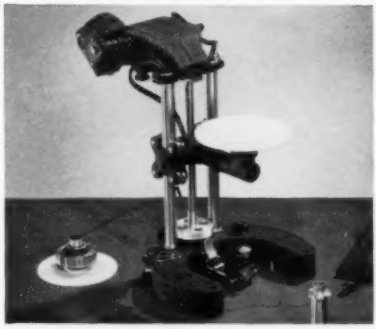

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"Down here on the Florida keys, land is scarce and credible monuments are few. In the absence of the usual landmarks, accuracy (I prefer the word *precision*) is paramount. We are, therefore, forced to use USC&GS monuments and local plane coordinates.

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"Here's how we do it: Transit is oriented first on a line using the grid azimuth calculated from local point coordinates of USC&GS monuments. Compass is set to read True Bearing of the line. Instrumentman then traverses by azimuth to the point of beginning of the survey. At each change in alignment, a backsight is taken with telescope plunged or inverted—after making certain forward azimuth on the back line is still properly set. The compass is released, telescope erected and sighted on next forward point. The line is measured and azimuth recorded. Compass reading is also recorded as a check.

"Now the upper motion is unclamped and a backsight is taken with telescope erect and back azimuth *read*. With the upper motion unclamped, a foresight is again taken. This should check the original azimuth of the forward line.

"This operation is repeated at each change in alignment back to point of beginning, where the forward azimuth should read the same as the calculated value. Thus, *back* azimuths are read each time and *forward* azimuths are double checked. In addition, constant reference to compass readings is made and all observable points-in-survey or known coordinated points are sighted.

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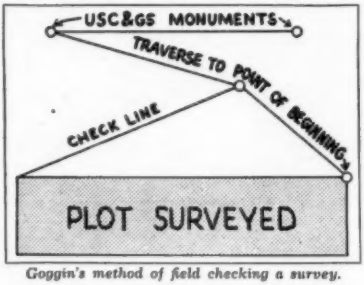

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The Thirteenth Annual Meeting

American Congress on Surveying and Mapping
Shoreham Hotel, Washington, D. C.
March 23, 24, and 25, 1953

Surveys and Maps Provide the Engineering Information Essential to Economic Planning and Development. This is the general theme which is being developed as plans are progressing for the Thirteenth Annual Meeting of the American Congress on Surveying and Mapping.

The program committee includes representatives from each of the six technical divisions, which will insure the inclusion of papers and topics of interest to all members of the ACSM. The exhibit committee is inviting an even wider range of commercial concerns than ever before to display their products and equipment at the annual meeting. March 23–25, 1953, has been selected as the date which should enable many to attend who cannot come to Washington in June. Informal gatherings and social functions to which the ladies are cordially invited will round out the three-day program.

Plan now to attend the Thirteenth Annual Meeting
Reserve the Dates—March 23, 24, and 25, 1953
Meet your friends at the Shoreham, Washington, D. C.

Our New President

Rear Admiral Robert F. A. Studds, Director of the United States Coast and Geodetic Survey, was elected President of the American Congress on Surveying and Mapping for 1953.

REAR ADMIRAL ROBERT F. A. STUDDS

He was born in Washington, D. C., December 17, 1896, where he received his early education and later was graduated from the Catholic University of America in 1917 with a degree in civil engineering. After completing his formal education he was employed briefly in the surveying department of the District of Columbia.

At the beginning of World War I, Admiral Studds entered military service and served with the 472nd engineers until 1919. On being discharged from the Army in 1919 he entered the commissioned service of the Coast and Geodetic Survey where he served successively through the various ranks to his present position. Twenty-three years were spent on field duty including command of a number of survey ships. Among his many important field assignments in hydrographic surveying was the execution of the first surveys along the rugged north coast of the Island of Luzon, largest of the Philippine Islands. This work was especially difficult and hazardous since it had to be accomplished along a desolate strip of coast in the path of devastating typhoons.

Admiral Studds received a commendation in 1936 from the Secretary of Commerce for his expert handling of the ship *Fathomer* in Port San Vicente, Philippine Islands, during and after the typhoon of August 15, 1936. This was one of the most severe storms experienced in the history of the Philippine Islands. Because of the thoroughness and care with which the ship was prepared, damage resulting from the storm was held to a minimum.

During the last year of World War II, Admiral Studds commanded the ship *Patton* and was engaged on surveys in the western Aleutians. In 1946, after return of the ship *Pathfinder* from the Navy, he had charge of conversion of the vessel to Coast Survey service. Following this he initiated the surveys of the important commercial areas in Bristol Bay and Bering Sea. At the time of his appointment as Director of the Coast and Geodetic Survey, Admiral Studds was serving as Chief of the Division of Charts in the Washington office. Prior to this assignment, he was in charge of the San Francisco office of the Bureau where he served for several years as Supervisor of the Western District.

Admiral Studds has been an ardent supporter of the American Congress on Surveying and Mapping since its beginning. He has always given whole-hearted support to surveying and mapping and to matters pertaining to air and marine navigation. Among the many organizations in which he holds membership are the Society of American Military Engineers, U. S. Power Squadrons, Army-Navy Club, Washington Society of Engineers, American Geophysical Union, U. S. Naval Institute, Pan American Institute of Geography and History, National Geographic Society, the Institute of Navigation, and the American Shore and Beach Preservation Association. He was recently elected to Sigma Xi, national scientific fraternity.

Among his many published papers are "Coast and Geodetic Survey Data—An Aid to the Coastal Engineer," and "The United States Coast and Geodetic Survey—Its Works and Products."

The Value of Control Surveys to the Property Surveyor

By SOL A. BAUER

REGISTERED CIVIL ENGINEER AND SURVEYOR, CLEVELAND, OHIO

WHEN I was asked to speak on the value of control surveys to the land surveyor, my first reaction was that the subject was so axiomatic that it needed no proof. I, therefore, answered that a discussion of the value of control surveys seemed to me to be somewhat in the nature of an argument in favor of the Ten Commandments. The rejoinder to that suggestion was the statement that the Ten Commandments have supplied material for untold sermons since they were first expounded, in spite of their general acceptance, and accordingly, I should accept this assignment. Therefore, this paper should begin with a Biblical quotation. But, being no authority in that field, I shall let each of you select an appropriate verse and line as you see fit, and you each might select your own Commandment as representing the one under discussion.

One might well wonder why a property surveyor should question the value of control surveys, for some form of control is an essential part of almost every property survey. There might be some argument as to the form that control should take, and the precision it should have, but control of some kind seems beyond question. Nevertheless, I have witnessed among my colleagues considerable opposition to the use of control surveys.

In my home city of Cleveland, we are extremely fortunate in having had a city geodetic control survey in process of development during the past fourteen years under the guidance of G. Brooks Earnest, president of Fenn College.

That survey has already established coordinates of great accuracy for approximately 1,600 monuments in an area of about 400 square miles. The monuments are in pairs—within the urban area at intervals of approximately 1 mile and elsewhere in the area spaced approximately at 2-mile intervals. The descriptions, references, coordinate values, and elevations of these monuments are published in pamphlet form as soon as each section is fully closed, adjusted, and completed.

With such control available for use, it might be assumed that all private practitioners and public survey offices are making constant use of it for most survey purposes. The strange truth, however, is that mine is probably the only office that makes fairly regular use of the control. To my knowledge, no other private office uses the control except for elevations, and only on occasion do the public or government survey offices avail themselves of the horizontal control. A fair question, then, is: With such control so readily available, why is it not being used more fully? It might be that we surveyors are a hard-boiled lot, difficult to convince, and probably too proud of our individuality. All this, of course, indicates that some argument is necessary to prove to my colleagues that a horizontal control system has value.

In my practice, we have had two notable examples that, I think, should prove not only the value of horizontal control but also the fact that no other method of surveying could have served as a substitute.

In one case we were called upon to make a survey of a steel-mill property, including, besides the outline survey of the property, the location of some 40 miles of winding railroad track within the property, as well as other fixed objects—all coordinated at intervals of approximately 100 feet to the nearest one-tenth of a foot. The property was roughly triangular in shape and approximately 350 acres in size.

A pair of geodetic monuments was near each apex of the triangle. Our first step

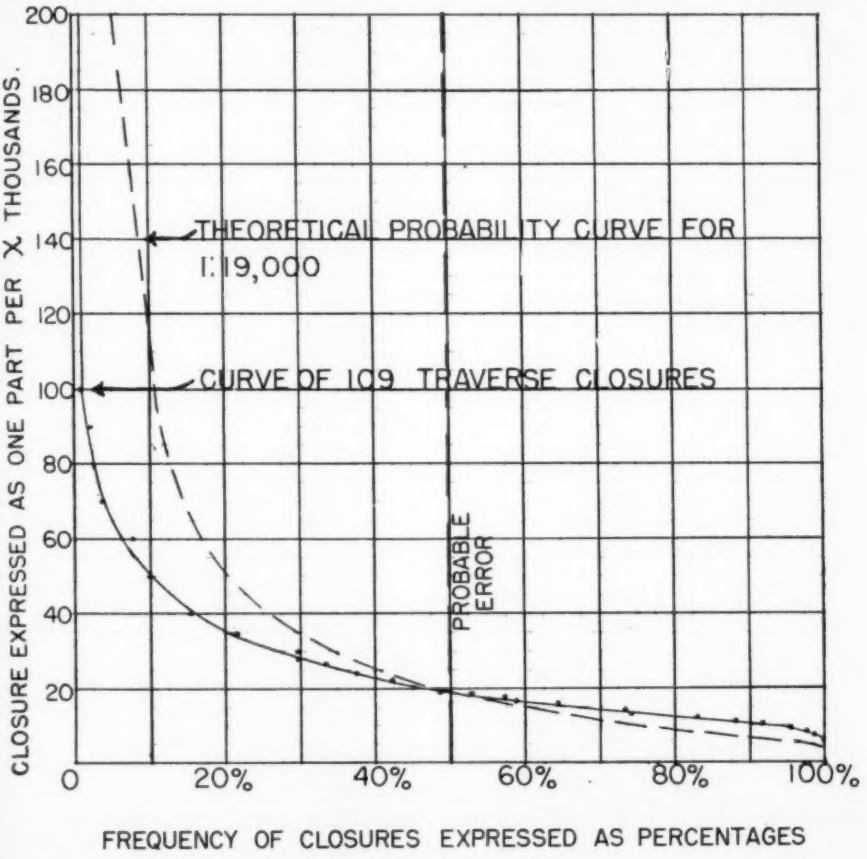
Presented at the Twelfth Annual Meeting, American Congress on Surveying and Mapping, June 11–13, 1952, Washington, D. C.

was to traverse between the three pairs of geodetic monuments. These three traverse closures were: 1/13,500, 1/19,500, and 1/39,000, with a mean closure of 1/19,900. The shortest traverse was 5,800 feet, and the other two approximately 9,500 feet each, for a total of 24,800 feet.

We then broke these traverses down successively into a series of smaller and smaller traverses, in order to locate the many miles of winding track on the property. In total, we ran 109 such internal traverses, closing from one previously adjusted point to another. In that way we established a control system consisting of approximately 500 traverse points throughout the property. The mean closure of these 109 traverses was 1/16,900, and the median value was 1/19,000. The total length of traverses was 29½ miles. The traverses varied in length from 400 to 5,000 feet.

For a clearer representation of the closures thus obtained, I have plotted those 109 traverse closures in a frequency-precision curve on the accompanying drawing. The solid, heavy line in the diagram represents, by percentages, the frequency of the various closures obtained, expressed as one part in X thousands.

The curve represented by the dashed line is a theoretical probability curve in terms of frequency for a uniform accuracy of 1/19,000. This theoretical curve represents the frequency with which errors of more or less



than the true probable error (in this case, 1/19,000) will occur through the operation of the Law of Probabilities and the compensation of errors. By definition, the probable error is at the 50% or median point. The close similarity of the curve plotted from actual observations to the theoretical probability curve indicates that (*a*) the work followed a consistent level of accuracy; and (*b*) that level of accuracy is approximately 1/19,000, or a probable error of 0.00526 foot per 100 feet.

To digress slightly, if I may: In 1943 a paper of mine entitled "Relative Angular, Linear, and Traverse Accuracies in City Surveys" was published in the *Transactions of The American Society of Civil Engineers.* That paper represented a study of actual accuracies obtained in the regular course of the work of my office in the period of 15 years preceding the paper. All the traverses studied in that paper were closures upon the point of beginning, for at that time our geodetic control was in its infancy. The mean traverse closure in that study was found to be 1/22,600, with a median value of 1/27,500. In the discussions of the paper, Professors Kissam, Rayner, and Earnest properly indicated that such closures were not necessarily an indication of accuracy, but only an indication of consistency of procedure. In my final discussion, I attempted to hypothesize, on the basis of the statistics I had assembled, the actual accuracy our procedures would develop, when applied to our completed geodetic control.

Without repeating the discussions in that paper, I arrived at a calculated mean value of 1/18,000 as representing our true accuracy as it should appear with the same procedures applied to traverses between fixed geodetic control monuments. You will note that the three closures given above between the geodetic monuments averaged approximately 1/20,000. The closure of 1/17,000 for the 109 interior traverses is slightly under our hypothetical value, but this is understandable because of the increasing remoteness from the original control. In any event, the results indicate a fairly high accuracy for traverse control.

The purpose of going into this detail is to indicate the extent to which substantial accuracy can be obtained by ordinary plane surveying methods within limited areas. The survey methods and equipment used were the standard methods we use and have used for years in all our work, and which we vary only slightly from job to job to meet changing conditions. (I might say that, in our practice, which is limited almost exclusively to our metropolitan area, we have found that it is more efficient and more economical to use one procedure on all similar work, and to train our men accordingly, than it is to attempt to vary our procedures from job to job. We find that the men tend to fall into a pattern of operation, and that the pattern is changed only at the expense of time, whether the change is for an increased or decreased accuracy.)

We have been on the steel-mill job described above for more than 2 years. During that time many changes have taken place in structures, tracks, and topography, and it has been necessary to relocate certain tracks and structures, as well as points previously set.

We are still able to reproduce points with a relatively high degree of accuracy, even though much of our control has been destroyed by construction. With the network already established, I am confident that at almost any time in the future we shall be able to relocate, with a fairly high degree of accuracy, any point needed, unless all our points and the surrounding geodetic control are destroyed.

No system of references, no isolated lines, no separate base-line method or grid system, would serve the purpose which is met so well by the geodetic control.

On another occasion, some years back, we were called on by two corporations to locate approximately 1,000 feet of a bend in a river. This bend was to be filled in because of a river-straightening project. The thread of the stream, as it originally existed, formed the property line between the two corporations. We were to determine the position of the waterline edges of the river, and establish a centerline which, by agreement, would

become the fixed property line between the two corporations. The land was in a part of our industrial area, at that time undeveloped. Our instructions were to set enough monuments so that the points could be reproduced after the fill had been made. As the whole area was low river bottom, and afforded no basis for reference, we extended the survey a considerable distance to the north and to the southwest, in order to have a tie-in in two directions to the nearest pairs of monuments of any permanence.

We then ran a traverse loop closing upon itself between these two pairs of monuments, for at that time the positions of the monuments had not yet been determined by the geodetic survey. Subsequent to that time and that survey, we made some six or seven additional surveys in the vicinity of our traverse, for a variety of owners, all of which surveys we tied into the traverse we had run for the original work.

At the start of World War II it was suddenly decided that a blast furnace was urgently needed in this locality. Most of the parcels of land on which we made the several surveys just referred to were included in the land acquired for the blast furnace, together with connecting lands, to form a combined area of some 250 acres. The urgency of the situation did not permit anything more than such additional surveys as were necessary to fill in the spaces left between our previous surveys. No time was available for an enveloping survey. In fact, no time was available even to prepare a new survey plat of the entire area. The survey plat that is now recorded in the deeds is actually a composite of several separate survey plats which were trimmed and fitted to each other and photographed, so as to form a new tracing to which such new data as were necessary were added to complete the drawing. This composite plat was made possible due to the fact that all the original drawings had been prepared at the same scale, coordinated on the same grid and control, and all drawn by the same draftsman, so that the composite has the appearance of a single drawing. Subsequent to construction (during which changes of elevation of as much as 30 feet took place) resurveys were run in order to plot new facilities and structures. At no time did any lines subsequently run between such points as were left close with an error of more than 1/11,000.

None of this saving of time would have been possible, of course, had we not gone beyond the immediate demands of our first job in this area. The expansion of the first small survey into the survey of an assembled parcel totaling 250 acres would have, of course, resulted in a loss of accuracy to the point that there would have been no rigidity left to the outline of the large tract, had we not taken precautions at the beginning. The accuracy that was developed was possible only because of the original establishment of control of a high degree of accuracy. Moreover, this control extended considerably beyond the enveloped area.

At this point I can hear my colleagues say, "Yes, but who is going to pay for all that extra work under normal circumstances? The government will not always come in and pick up the check by building blast furnaces to pay for the excess surveying you have done!"

And here we probably reach the real reason for hesitation in the use of horizontal control by the private practitioner—the extra work necessary to tie in. My answer is that a definite part of that extra surveying is a part of the "second mile" that the professional man must of necessity travel in order to establish his professional integrity and professional status. We are not professional men when we merely perform so many hours of service for so many dollars. As professional men we must go beyond that which we are obliged to do under immediate contractual arrangements.

Furthermore, it is good business for a practicing surveyor like myself, who intends to stay put and operate within a confined area, to invest time and effort in his future and his reputation.

The probability of additional work, the probability and often the necessity of rechecking, and the advisability of building a factor of safety in terms of more-than-necessary accuracy to compensate for the

deteriorating effects of time—all these make it good business policy and good economics for the practicing surveyor, operating as most of us do, to prepare for such eventualities.

In both cases cited above, the establishment or existence of a large control system saved the day in a manner that could not have been done by any other expedient. There is a limit, of course, to the extent to which a practitioner can go economically beyond the immediate requirements of his job. It is my belief, however, that we practitioners are sometimes inclined to underestimate the amount of such extra surveying that we should accept as a part of our professional responsibility.

Communities that have a good control system are fortunate, but are all too few. But the value of control can be attained, and often without much increased expense, particularly by city, county, and State engineering departments, merely by the expedient of extending such surveys as are made in the normal process of the work until they tie in by some method, if only by traverse loop, to other previously made surveys. If nothing better than a series of rather loose traverses is available, still that form of control, however weak, is better than no control at all. Moreover, the accuracy of such control is likely to be increased through reruns, diagonal ties, and the running of cutoff lines.

As indicated above, plane surveying methods with careful procedures can develop control of fairly high accuracy, suitable for limited areas. In any event each survey can be made to augment previous work, tending toward a higher accuracy and the development of a skeleton or framework to which additional work may be tied. Ultimately, the establishment of a few triangulation stations would serve to tie the entire net more tightly into a dependable system of determinable accuracy.

The present method, so widely used by public survey agencies, of surveying each road, street, building, bridge, or culvert separately and independently of other surveys, leads no place but to further repetitions of surveys with no higher accuracy ever obtainable. It is probable that many of our cities have spent more money in resurveys of the same streets and roads, without increasing the sum total of their survey information, than they would have spent had they extended their surveys beyond the immediate needs and built up a constantly increasing network of improved control.

I think it is safe to say that, as yet, no other method can replace the use of horizontal control in its functions of facilitating the surveying of land and in the replacement of land corners. I can only say to my fellow practitioners that such additional effort and expense as may be involved in the use of such control is good engineering economy and a part of our professional obligation. We surveyors, particularly we private practitioners, like to talk about the injustices done us—and they are many.

But the surest way for us to overcome those injustices is for us to take the initiative by acting in accordance with the professional principles and responsibilities to which we lay claim. We must be willing to do a little more than just enough. If we do, we shall soon gain for ourselves the prestige and privileges that we feel are due us, and in so doing we shall overcome the principal impediment that stands in the way of the general use of horizontal control in property survey work.

Michigan Land Surveyors to Meet

The Michigan Society of Registered Land Surveyors is planning a 3-day annual meeting at the Park Place Hotel in Traverse City, Mich., on February 5, 6, and 7, 1953. Plans for the meeting, which is under the direction of the Northern Chapter of the Society, include a joint meeting with the Michigan Bar Association and the Michigan Title Association. ACSM members and other land surveyors are cordially invited. For further details write George D. Henning, President, Michigan Society of Registered Land Surveyors, Roscommon, Mich.

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Selection of Contour Intervals

(*A Panel Discussion*)

One of the highlights of the Twelfth Annual Meeting of the American Congress on Surveying and Mapping at Washington, D. C., June 11–13, 1952, was the panel discussion on "Selection of Contour Intervals," held under the auspices of the Topography Division of the Congress, of which Calvin S. Maltby is Chairman. Alfred O. Quinn, of the Aero Service Corporation, acted as moderator of the panel.

This panel is concerned with a most important subject in the field of topographic mapping —namely, the scale, contour interval, and accuracy of topographic maps. The following papers by Leon T. Eliel, Louis A. Woodward, Aubrey H. DaSantos, Shirley V. Griffith, and Robert H. Lyddan, represent the opinions of experts on this particular subject. Following the five papers are comments and discussion from the floor.

—EDITOR

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A Practical Approach to Scale, Contour Interval, and Accuracy

By LEON T. ELIEL

VICE PRESIDENT, FAIRCHILD AERIAL SURVEYS

A MAP ordinarily should be made at the smallest scale and largest contour interval that will serve the purpose for which it is intended. Large scale and small contour interval are very expensive luxuries, unless they are positively needed.

The scale of a map is usually governed by two factors: (1) Accuracy, and (2) space and size.

ACCURACY

Any map that gives a complete picture of an area will serve almost every purpose until the user starts to scale distances or determine directon from it. For example, we can cite an aerial photographic contact print. If the ground is flat and the camera level, this contact print is an accurate map. We can scale as closely as we wish and the map will prove good; angles are correct. But then, suppose the same picture were exposed with the camera slightly tilted. It is no longer a map, but it is still a very complete picture. We can measure on it but not with quite the same degree of accuracy, and the angles taken from it will be close but not absolutely accurate. For many purposes this picture may still be satisfactory.

A map needs to be accurate enough so that errors in measurements will not cause losses in dollars and cents greater than the cost of making the map more accurate. Thus, consider a map made for fire-insurance purposes where the fire rate increases if buildings are closer together than 8 feet. If the code states that in such instances the distance between walls must be measured to an accuracy of 1 inch, then, inasmuch as the map cannot be scaled to any such accuracy, its function becomes that of an inventory. It will show the marginal cases where measurements on the ground will be required. Here is an instance where some data are required with a high accuracy but the map may be made with a lower accuracy.

A mechanical drawing is a sort of map. It is usually drawn carefully to scale, but is intended for scale measurements only in a most general way. The distances and toler-

ances are given in figures. For instance, a certain part may be specified to be 1.573 inches long. Obviously the map (drawing) cannot be scaled with any such accuracy.

A map for use in determining the capacity of a potential reservoir may properly be a rather rough job, because the imperfections usually average out. However, the top contour, or flood line, must sometimes be mapped or surveyed very accurately because it defines the line of land acquisition and is an index of the amount of money involved in damages. It is usually very wasteful, however, to survey an entire reservoir with the accuracy needed for the top contour. It is nearly always cheaper to run this top contour by ground survey, especially if the terrain is fairly flat.

In highway engineering, on the other hand, the map itself is the actual basic data from which the highway is located and designed. It should be quite accurate and should be at a scale of 1 inch = 200 feet, or even 1 inch = 100 feet, with 5-foot or 2-foot contours. If the map proves unreliable, the alinement may be affected for a substantial distance. Thus, expensive corrective surveys have to be made on the ground, and the construction contract may be affected if it was based on incorrect quantities computed from the map. In this case a cheap map of poor quality is an extravagance. If, however, a highway is being located in comparatively virgin country, a smaller-scale map is indicated for the reconnaissance stage of the studies, where the problem is to get an approximate preliminary location. By way of illustration, a proposed highway location was mapped on one side of a river at a large scale and small contour interval. A study of this map suggested that possibly the other side of the river should be used. So a second strip was mapped in detail. It would have been cheaper to map both sides at a small scale and large contour interval for the purpose of making a preliminary location. Then a narrow strip could have been mapped at a suitable scale and interval for the final location. In this case two large-scale strips cost more and were less effective than a small-scale wide strip and a large-scale narrow strip.

SPACE AND SIZE

The second factor determining the scale of the map is the combination of space and size. An engineer may want space for the layout of construction details. He may not, and probably does not, need extreme accuracy, as the project will, in any event, ultimately be staked by ground survey. A map specified at a large scale for this purpose may be wasteful because, ordinarily, large scale connotes high accuracy, and high accuracy costs lots of money. This engineer should buy a map made to small-scale standards of accuracy. Reproducing it at a large scale to afford working space involves only the simple and inexpensive procedure of photographic enlargement. This engineer doesn't need accuracy, which is expensive; but he needs space, which is cheap.

Size requirements enter into the decision if maps have to conform to a certain filing system, or if a map must be small enough for convenient handling in the cockpit of an airplane and, at the same time, cover enough ground so that a fast-moving airplane doesn't fly across the sheets faster than the pilot can change them. For the age of space ships, a good map scale may be one to ten trillion. The earth and sun will be about half an inch apart on such a map.

CONTOUR INTERVAL

Very accurate photogrammetric contours cost more money than less accurate contours. As it is customary to expect half-interval accuracy in contour maps, we may say that small-interval contours are expensive. It should be kept in mind, however, that it is the accuracy rather than the interval which is the main factor of cost. This accounts for the fact that when spot elevations are required to be twice as accurate as contours the cost of a photogrammetric map doubles or trebles; or else the spot elevations must be established by ground survey, thus perhaps defeating the purpose of a photogrammetic survey. The accuracy of these spot elevations governs flight height, amount

of control, and the number of models to be set up. A sensible way to call for spot elevations is to state, "Spot elevations shall be measured photogrammetrically and recorded to the nearest foot."

For most engineering purposes a scale-contour relationship should be selected which, insofar as possible, avoids densely drawn contours. When contours are closer than 12 to an inch the drafting costs start skyrocketing. It is doubtful whether contours drawn closer than 12 to an inch are of any real practical value. Where they run 50 to an inch the cost of drafting may well be more than all the rest of the costs combined.

Where a survey covers a large area of which a small part will ultimately be required at a high accuracy, the mistaken idea is often encountered that the whole project should be done with the higher order of accuracy. A typical example is a survey of a reservoir covering 50,000 acres in which is a dam site covering 10 acres. Perhaps the engineer doesn't yet know which dam site will be selected. He thinks that it costs a lot of money to take the aerial photographs, so the area had best be photographed so that any part can be prepared at the maximum accuracy that might be needed. He may be right in a sense, but actually the aerial photography is usually such a small percentage of the total cost that the project can well be flown twice, once for the dam site which may require a scale of 1 inch = 100 feet, wth 2-foot contours, and again for the reservoir, which may require a scale of 1 inch = 1,000 feet, with 10-foot contours. No procedure is so wasteful as photographing a large area for mapping at a large scale just because some small part of it may ultimately be needed at that scale. After these large-scale photographs have been taken, little is saved by drawing 10-foot contours from them instead of 2-foot contours. The main cost pattern is set when the photograph scale is chosen.

Under some conditions a requirement for horizontal accuracy of contours as well as vertical accuracy would be advantageous. In flat reservoirs there is a particular need for this. To illustrate, suppose a reservoir had only one 5-foot contour which ran a mile back from the dam. If this contour were one-half interval in error it might extend only a half-mile back from the dam and a 50 percent error in the calculated capacity would result. The same general kind of error may result in any flat part of a reservoir. In such instances the accuracy usually associated with a smaller contour interval would be desirable, except for cost. Specifying the horizontal accuracy of contours has the cost effect of specifying a much smaller contour interval. Careful consideration should be given to the effect of such an error on the calculated capacity, percentagewise. An occasional ground profile across flat places, which can be run at the same time that the photogrammetric control is being established, is often the best and cheapest solution.

Some engineers are inclined to think that our present accuracy standards are sometimes overdone. In steep country, for example, it seldom makes much difference to any user whether 90 or 75 percent of the contours are correct within a half interval. It makes a terrific difference, though, in the cost. The 75 percent map will usually cost less than half of the 90 percent map.

This brings up some maxims of photogrammetry, with which this paper will close:

1. Large scale with its implied high accuracy costs money. Working space should be provided by enlargement.

2. Small contour interval with its implied accuracy costs money. Properly spaced contours of less than "standard accuracy" can depict land forms well and may serve the purpose at less cost.

3. Accuracy in itself is not a justifiable goal. Unless it is needed it is wasteful. For sound engineering, the smallest scale, the largest contour interval, and the lowest accuracy that will provide the necessary engineering data should be specified.

Scale, Contour Interval, and Accuracy for Special-Purpose Maps

By LOUIS A. WOODWARD
VICE PRESIDENT, JACK AMMANN PHOTOGRAMMETRIC ENGINEERS

MR. ELIEL has made a very complete and very accurate overall statement regarding scale, accuracy, and contour intervals for special-purpose maps. For the sake of emphasis, I would like to repeat his closing remarks, "Accuracy in itself is not a justifiable goal. Unless it is needed it is wasteful. For sound engineering, the smallest scale, the largest contour interval, and the lowest accuracy that will provide the necessary engineering data should be specified." In emphasizing this, I certainly do not mean to imply that very accurate, large-scale, small-interval, special-purpose maps are not well justified for many purposes.

NEED FOR A FORMULA

The problem is: How can we apply the various factors of the map requirement to determine the proper scale, size, accuracy, and contour interval needed? Unfortunately, we do not seem to be able to develop a formula that will give us a clear, concise answer. Until some such formula is developed it seems that there is no substitute for mapping experience, and it is strongly recommended that an engineer thoroughly versed in surveying and mapping be consulted during the early stage of project development. This should result in having the type of maps required when they are needed. Very few people realize the number of special-purpose maps required for various types of engineering projects. During the past few years the requirements for this type of map have increased considerably and there is every indication that the volume will continue to increase. One of the reasons for the increase in special-purpose mapping is that photogrammetric methods have been developed to where they can produce special-purpose engineering maps for a large percentage of such map requirements at costs substantially below those of field methods and in considerably less time. I believe this ever increasing volume of special-purpose mapping will continue, regardless of the number of standard quadrangle or general-purpose maps produced by agencies of the Federal Government.

The only thing that can retard special-purpose mapping is the map-making profession itself, and I believe Mr. Eliel had this in mind when preparing his paper. If we, as map makers, attempt to convince a map user that he needs a hundred-dollar map when a ten-dollar map will do his job, we are hurting no one but ourselves and our profession. The same thing applies to accuracy.

Special-purpose maps are just what the name implies—maps compiled for some special purpose—and, generally speaking, they are of little or no value for other purposes, although the horizontal and vertical control established may frequently be used for other purposes. Therefore, the entire cost of a special-purpose map must be economically justified on the basis of the project being considered. We have found that most purchasers of special-purpose maps are extremely cost-conscious and justify the expenditure for maps in relation to their value to the over-all project. It is a rare occasion when individuals or companies spending their own money order luxury maps. Where a single aerial photograph will provide the necessary data, funds are seldom, if ever, spent for a mosaic or a planimetric or topographic map. I can best develop this point by briefly describing some special-purpose maps, their specifications, and the reasons for the contour interval, scale, and accuracy.

TOP ACCURACY PAID IN THIS CASE

The most accurate and expensive special-purpose map I know of, and possibly one of the most costly maps per acre ever compiled, was one recently required by the Humble Oil and Refining Company of Houston, Tex. The map information was required in connection with litigation involving the title of 24 sections of land within an area about 18 miles long varying from 2 to 8 miles wide in the eastern part of Kenedy County, Tex. The question at issue was whether these sections were a part of Laguna Madre or, through the process of accretion and reliction, had become a part of the upland estate. To prove this, a very accurate topographic map was required of the Laguna Madre flats. Except for several overgrown mounds and hillocks, the surface of the flats is very smooth and devoid of vegetation and other cultural detail. Frequently a horizontal distance of 1,000 to 2,000 feet would show an elevation differential of no more than 0.10 foot.

It was necessary to prove to the satisfaction of the court whether all or any part of a 24-section area was above mean high tide. It was believed that the elevation of the area in question would vary from zero to as much as 2 or 3 feet with reference to local mean high tide. In view of the character of the terrain and the detail and accuracy required of the map information, it was decided that a contour interval of 1 foot or even 0.5 foot would not adequately portray the surface of the flats. Hence, a contour interval of 0.2 foot was decided on. The compilation scale selected was 1 inch = 2,000 feet because of the relatively few contours in the area and the almost total lack of planimetry. Extensive geological investigations had been made in the flats area, and the positions of all bore holes had to be determined both horizontally and vertically.

Photogrammetric methods were considered for this project, but they were discarded as not practical. Field methods were used exclusively to obtain the map information. Approximately 500 miles of third-order traverse and 800 miles of second-order levels were required to obtain the necessary data. All level lines were tied in to the U. S. Coast and Geodetic Survey precise level network. All traverses originated and terminated at U. S. Coast and Geodetic Survey triangulation stations. A Lambert Plane Coordinate System was used for the project.

It was necessary to determine and locate on the ground the line of mean high tide which would constitute the boundary between the sea and the upland estate. To do this, several automatic tide gages were established and operated for more than 2 years. In the North Basin of Laguna Madre mean high tide was found to be 0.01 foot above the 1929 mean-sea-level datum of the U. S. Coast and Geodetic Survey, and in the South Basin it was found to be 0.42 foot above it.

The end product was a lithographed topographic map at a scale of 1 inch = 8,000 feet, which was used as an exhibit in the court.

Anyone who is at all familiar with the cost of survey and mapping operations will readily recognize that the cost of obtaining these data was considerable. However, for those who have not had the pleasure of being closely associated with the oil industry, I shall make a few assumptions and do some simple arithmetic to show the possible value of this map. The 24 sections involved include about 15,400 acres and one oil well will be authorized on each 20 to 40 acres. To be conservative, we will assume that one oil well on each 40 acres will be authorized, which would provide for 385 well locations. Again, to be conservative, let us assume that half of the wells drilled in the area will be dry, which would leave 192 producing wells. Oil production in southern Texas averages from 45 to 150 barrels per day, so, again let us be conservative and assume an average production of 50 barrels per day per well. This would give a daily production of about 9,600 barrels of oil for the 192 wells. At present, oil at the well sells for about $2.65 per barrel which would amount to a little over $25,000 per day, or about $9,500,000 per year. Most oil wells in this

area will produce from 20 to 40 years, so, again to be conservative, we will assume a 20-year production period. On the basis of these conservative assumptions, this particular special-purpose map involves a minimum sum of about 190 million dollars. The substantial per-acre cost of this map was relatively small when consideration is given to the over-all project; in fact, the map cost was only an infinitesimal fraction of one percent of the amount involved and it was most certainly a well-justified expenditure.

CONTOUR INTERVALS OF 2 FEET OR LESS

Generally speaking, I do not believe photogrammetric methods compare favorably with ground methods of mapping where the contour interval is less than 2 feet, except in severely eroded areas or where the area contains a considerable density of planimetry. Special-purpose maps of residential and industrial areas being considered for railroad and expressway location, and design and detail plans for redevelopment of slum areas, are examples of mapping jobs where photogrammetric methods have a decided advantage over field methods. Topographic maps at scales of 1 inch = 40 feet, to 1 inch = 100 feet, are required to show the data that location and design engineers need. Contour intervals for this type of map in relatively flat areas are generally 1 foot or 2 feet. Standard accuracy is generally a minimum requirement for such maps. This type of map generally covers a strip from 1,000 to 2,000 feet in width and, in addition to contours, accurately shows all planimetric features of sufficient value to be of concern to the engineers charged with the responsibility of location and design. Such features, in addition to the houses, streets, railroads, and drainage, that are usually shown on small-scale maps, include all buildings, telephone, power, and telegraph poles, fire hydrants, manholes, storm-sewer inlets, the legal street widths, individual trees, fences, walls, driveways, and alleys. Currently, we are making this type of map at three different locations. In each case the engineers will be able to make their final location and final design directly from the maps. When final approval is given and funds are made available, these jobs can be staked out on the ground and construction started.

MAPS FOR LOCATION OF TRANSMISSION LINES

Special-purpose maps compiled by photogrammetric methods have certainly been of tremendous value in transmission-line location and design. Standard accuracy is seldom required in this type of map. For such maps a reasonable degree of horizontal accuracy is required; however, the primary concern is relative elevations of adjacent pole or tower locations. A power company frequently will make a tentative line location entirely from a stereoscopic study of contact prints and then call for a strip of topography only a few hundred feet wide with a profile along the designated line. The primary objective here is to locate a line that will not require extremely high towers and to be sure that, with the tower heights and locations selected, there will be sufficient clearance between the line and the ground or other obstructions.

SIZE AND SPACE

As pointed out by Mr. Eliel, size and space are frequently critical items of consideration in special-purpose mapping and, in some instances, are of equal importance to accuracy. We are now completing for a large public utility company a series of approximately 6,000 map sheets, known as Record-Keeping-System Maps. Although accuracy was a factor of consideration in developing the specifications, space and size were extremely critical. The company had a set of obsolete maps and the necessary filing facilities for handling them; therefore, the sheet size selected was necessarily the same as the old maps. There are three series of the new maps. The first series was required for use as a base on which to show all primary electrical circuits and facilities, the second set to show all secondary electrical circuits and facilities, and the third to show all gas transmission and distribution facilities. Discussions with the engineers of the company brought out that

(*a*) accuracy of position was not particularly important, (*b*) only reasonable scale accuracy was needed, (*c*) completeness of detail was extremely important, (*d*) space was extremely critical, and (*e*) legal street widths were required. The three scales decided on were 1 inch = 800 feet for the primary-electrical-circuit maps, 1 inch = 200 feet for the gas-transmission-and-distribution maps, and 1 inch = 100 feet for the secondary-electrical-data maps. These large scales were required in order that sufficient space would be available to show all necessary gas and electrical facilities. It was decided that new aerial photography was necessary to obtain the completeness of detail required. The accuracy specifications for the maps at a scale of 1 inch = 800 feet required that "any measurement of 10 inches or more between features on the map or maps when converted to the distance based on the scale of the map should not be at variance with the ground distance between the same two points by more than one percent." The streets, roads, etc., on this series of maps were shown by single lines. The series of maps at a scale of 1 inch = 200 feet was made by photographically enlarging the 1 inch = 800 feet maps, plotting one half of the legal street widths on each side of the street as plotted from the aerial photographs, and redrafting these data. It was quite a research project to determine the legal street widths and also the correct street names. The 1 inch = 100 feet maps were photographic enlargements of the 1 inch = 200 feet maps on linen. The one percent accuracy of the 1 inch = 800 feet maps, even when enlarged to 1 inch = 200 feet and then to 1 inch = 100 feet, was considered sufficient for these large-scale maps. This entire series of maps will be completed in about 430 calendar days or an average of about 14 maps per calendar day for the entire contract period. This includes the time required for aerial photography, field control, street-width determination, and all other operations.

ACCURACY—GENERAL-PURPOSE MAPS VERSUS SPECIAL-PURPOSE MAPS

We, in the map-making profession, talk a lot about standard accuracy and, from a professional-pride standpoint, I believe we all, personally, would prefer to make all maps as accurate and complete as possible. For general-purpose mapping, I subscribe whole-heartedly to our standard accuracy specifications. Examples of general-purpose maps are the quadrangle maps produced by agencies of the Federal Government and city maps generally prepared by commercial mapping organizations for the cities. General-purpose maps are used for numerous purposes, many of which require standard accuracy.

The special-purpose map is something entirely different. The accuracy, scale, detail as shown, etc., may be far above, equal to, or far below what we term standard accuracy. In the special-purpose map we are dealing in cold, hard economies, and maps must be designed, methods developed, and maps produced in keeping with the over-all requirements of the purchaser.

Contour Intervals for the Construction Engineer

By AUBREY H. DaSANTOS
VICE PRESIDENT, LOCKWOOD, KESSLER & BARTLETT, INC.

SPURRED ON by the accelerated program in the construction field today, the construction engineer has demanded that the photogrammetric profession supply accurate topographic maps to supplement his normal survey facilities. The acute shortage of qualified surveyors, computers, and draftsmen has introduced the engineer to mapping methods involving lenses, prisms, mirrors, and, no doubt also, the proverbial crystal ball. As a result, he has been prone to accept specifications incorporating requirements peculiar to other special-purpose maps.

Contour interval, as pointed out in the previous papers, is dependent on several factors. However, it is up to the photogrammetrist to employ the methods and equipment necessary to obtain the required accuracies. Our standard specification, which states that 90 percent of the contours shall be correct within a half contour interval, is generally the same as that of the American Society of Civil Engineers standard procedure for city surveys. The recent and continuing acceptance of topographic maps prepared by photogrammetric methods, as a basis for letting construction contracts, is evidence of their quality.

STREAMLINING THE MAPPING AREA

With economy and delivery time as two of the important factors in the selection of contour interval, more thought must be given to streamlining the extent of the area to be mapped. Requests for highway location maps have generally specified a scale of 1 inch = 200 feet with 5-foot contours for a 1-mile width, with the additional requirement that centerline traverse monuments, along with bench marks, shall be established for use in final location and cross-section surveys. This additional requirement partly nullifies the great saving that could be realized through aerotriangulation and utilization of existing control.

One of our current projects for a State highway department has taken advantage of the possibilities of photogrammetric methods by confining the mapping area to a strip 1,000 feet wide and increasing the width to 2,000 feet in the vicinity of proposed interchanges, with greater effort concentrated in furnishing topographic detail. Upon receipt of the aerial photography, location engineers coordinated their reconnaissance data with a stereoscopic examination of the photographs, permitting them to define the proposed areas for the interchanges. The decision to eliminate extensive monumentation was made because clearing operations for the construction invariably disturb or destroy many of the points and, in any event, a centerline baseline is required for the construction survey. Inasmuch as the 2-foot contours at a scale of 1 inch = 100 feet fulfilled the needs for earthwork estimates, most of the cross-section work has been eliminated. Enlargements of the final sheets at interchange areas to a scale of 1 inch = 50 feet are being made for delineation of construction details. It is interesting to note that very little additional control was established for the 2-foot contours as against the requirement for 5-foot contour mapping. The additional photography and compilation reflected by the larger scale and smaller contour interval resulted in an increase of only 15 percent over the cost of 5-foot contours.

APPROPRIATE CONTOUR INTERVALS

Preliminary reports for sewer studies invariably call for considerable field work employing differential levels. Although elevations are recorded from 0.01 foot to 0.10 foot along street profiles, 1- or 2-foot contour mapping is not necessary to replace the conventional ground method. The 5-foot contour map at a scale of 1 inch = 200 feet, supplemented by spot elevations to the nearest foot at all street intersections and breaks in grade, offers the consultant more complete information at a cost comparable to that of the level runs. The completeness of planimetric detail affords him a firm basis for studying zoning, district layout, street plans, house connections, easements, and a wealth of other factors, with a minimum of field investigation.

Another factor controlling the selection of contour interval has been the association of contour interval with final map scale. Some examples of this association are shown in the table below.

Map scale	*Contour interval*
1 inch = 40 feet	1 foot
1 inch = 100 feet	2 feet
1 inch = 200 feet	5 feet

Judging from our experience as engineers for the development of plant sites, housing projects, drainage, and location studies, the general necessity for 1-foot contours appears

to be unwarranted. If, as Mr. Eliel has pointed out, the engineer needs space, the 2-foot contour map can be plotted directly at scales up to 1 inch = 40 feet. This is a highly desirable feature in that construction details may be superimposed on the original drawings. The clearance of a proposed abutment can be scaled to within 0.5 foot at these large scales. The land surveyor, as well as the engineer, will realize material savings in cost and time by supplementing the large-scale map with a minimum of field editing. The location of party walls, the extent of roof overhang, subsurface utility data, and other vital details may be obtained by employing a two-man field party.

Engineers who use maps are primarily concerned with their accuracy and not with the methods of obtaining them. If the integrity and performance of the map-making profession are considered along with the requirements of the final product, specifications can be directed toward a statement of the required accuracy, with selection of contour interval being treated in a broader sense to meet the particular situation from the standpoint of accuracy, cost, time, and available manpower.

Contouring Problems on General-Purpose Maps

By SHIRLEY V. GRIFFITH

DIVISION OF PHOTOGRAMMETRY, U. S. COAST AND GEODETIC SURVEY

MR. ELIEL'S paper discusses the horizontal and vertical accuracy of special large-scale engineering service maps, their scales, and contour intervals. I agree with what Mr. Eliel has said in his paper, but find it very difficult to follow so many implied aspects. I am inclined to think that we cannot talk effectively in generalities about a subject that involves so many diverse aspects, among which are:

1. Two general procedures—planetable mapping and stereophotogrammetric mapping
2. Many map scales
3. Various contour intervals
4. Various horizontal and vertical accuracy requirements.

In order not to have to qualify too many statements, I shall confine my remarks to one kind of map—a general-purpose map, the standard topographic quadrangle at scale 1:24,000. The reason for confining my comments to these narrow limits will be obvious to those who have been compelled to make general statements regarding topographic mapping and have found themselves misquoted and misunderstood.

There are three points that I will try to make regarding the problem of contouring on general-purpose maps:

1. A solution to the problem of contouring in dense woodland
2. A solution to the problem of contouring in swamp and marsh
3. A suggestion for the selection of appropriate contour intervals.

MAP USES AND ACCURACY REQUIREMENTS

It is reasonably safe to say that the standard topographic map is one of the most widely used tools in the engineering profession. The uses to which they are put are sometimes startling. I have seen them enlarged to several times their intended usable scale and adopted as a base for city planning and for the layout of all sorts of municipal facilities.

Naturally, when put to such extensive and sometimes unexpected uses, the basic map data must be unusually excellent to accommodate them all. To reach this degree of excellence, standards have been established to assure a uniform horizontal and vertical accuracy and the use of standard symbolization throughout the map series. Under these standard requirements, we are assured that error in horizontal position of features is confined within very narrow limits and that there is legible and intelligible sym-

bolization. We know that the horizontal accuracy of maps made by photogrammetric methods almost precludes error in position of cultural features in excess of 40 feet on the ground or 1/50 inch at the 1:24,000 map scale, wherever adequate horizontal control is used.

The vertical accuracy of maps made either by planetable methods or by stereophotogrammetric instruments is an entirely different story. In open terrain the vertical accuracy of planetable or stereophotogrammetric mapping is unquestionably reliable, as numerous tests have proved beyond any reasonable doubt. However, in terrain that is heavily wooded or overgrown with dense cover, contouring to our vertical accuracy requirements is prohibitively costly, if the contour interval is 20 feet or less. It is my opinion that too much money and effort are expended in contouring such terrain with the same accuracy required for more valuable open land.

CONTOURING IN DENSE WOODLAND

Stated briefly, the vertical accuracy requirements are as follows: "Ninety percent of the points tested must be accurate within one half the contour interval." By planetable methods, the task of accurately contouring heavily wooded terrain is not impossible, but it is prohibitively costly; and by stereophotogrammetric instruments it is not impossible either, but it, too, is exceedingly expensive. To contour heavily wooded areas by stereophotogrammetric methods and assure compliance with the requirements sometimes may require that the area be photographed from very low altitudes and compiled at large scales; it may also entail establishing a much larger number of horizontal and vertical control points than usual. Furthermore, the compilation will have to be carefully tested in the field to be sure that its accuracy is adequate.

Too frequently, the limiting conditions of stereophotogrammetric contouring are established when a project is designed to be flown with "X" camera, at "Y" altitude, to be compiled on "Z" instrument, and to be provided with the barest minimum of horizontal and vertical control as shown on plan "A". In establishing the aforesaid conditions, the planning department sometimes pushes the limiting factors to the theoretical threshold of every phase of operation. Where any appreciable part of our map area is heavily wooded, our safety factor is not large enough to accommodate this limitation. The "X" camera must take pictures with utmost clarity and accuracy and with little latitude for film distortion. "Y" altitude provides the barest coverage and the minimum practicable overlap. The "Z" instrument must function at its maximum theoretical limit, with a very small factor left for the instrument operator's misjudgments or personal errors. Almost every horizontal and vertical control station available must be accurately located, with only small tolerances allowed for error in their *X*-, *Y*-, and *Z*-coordinates. Then, if everything turns out as expected we will emerge with a 1:24,000 scale map with 20-foot contours still theoretically obtainable by our method. But there are many things that can go wrong in a project that is set up in this manner. The photographs are rarely perfect in quality; slight film distortions may introduce unknown errors; partial vacuum failure in the camera is sometimes not discernible. Diapositives are seldom truly flat and introduce their small vagaries into the procedure. Horizontal and vertical control are seldom located 100 percent accurately or placed ideally in our models. And so it goes—small errors added to small errors become excessive error and the accuracy requirements are breached. Our *C* factors are based on the experience we have gained from frequent vertical accuracy tests, on past performance of our instruments and operators, and on a ground cover consisting largely of deciduous trees photographed during their leafless period, with the terrain having small open ground areas. Such conditions, however, do not always exist.

Evergreen cover is the great difficulty in stereophotogrammetric contouring because we are unable to see down through its dense canopy and our instrument operators grope for an obscured ground level. For example, small draws are completely obscured because of the tendency of trees to canopy at a more or less uniform level in their quest for an equal share of life-giving sunlight.

Field-completion surveys are supposed to test and complete the stereoscopic instrument work, but in dense woodland areas it is extremely difficult to do planetable testing and field completion. Here I think is where savings might well be made if we were to adopt more comprehensive and realistic requirements. In predominantly evergreen wooded areas we could and should relax our specifications. We might well consider lowering our accuracy requirements, permitting a full contour interval of discrepancy.

CONTOURING IN SWAMPS

We have a custom of eliminating a lot of contouring that is futile or unsurveyable. To cite a few examples, we drop contours where they get so close together that they will tend to coalesce at publication scale. We draw form lines over permanent snow fields and glaciers. We drop contours in small ditches and canals where it is impracticable to show them at the map scale. We omit contours from shifting sand, and in large sand dune areas we generalize them. We omit them from many distorted surfaces such as mine tailings and lava flows, and we may generalize them in any other badly broken terrain. My opinion is that we should extend this practice to include some other places where contouring is impracticable or might fail to comply with the specifications. For instance, in very extensive swamps and marshes, such as the pocosin areas of the Carolinas, the Everglades of Florida, and the swamps of Georgia and northern Florida, we could show the contours running into these areas without attempting to map them in the interior. We might even dash the contours through such areas to show that they are only drawn approximately. Either of these alternatives would be a less costly and more realistic presentation of the area, than an attempt to show actual contours.

APPROPRIATE CONTOUR INTERVALS

The contours on some maps are so close together that the printed map has brown blotches all over it when viewed at arm's length. This is usually the result of an arbitrary decision to a map a large area at a specified contour interval instead of selecting an appropriate interval for each separate quadrangle. We should probably be much better off if we specified the best possible interval for each quadrangle based upon a study of the average slopes in that quadrangle. I have been very much concerned about contour intervals for a long time, and I am convinced that a better solution can be obtained by starting off with a basic concept of appropriate contour spacing to provide reasonable vertical intelligence on the map and still not have the contours so closely spaced as to give unnecessary information. In other words, it must be determinable how close contours have to be spaced on our 1:24,000-scale map to show greater detail than is really usable and how far apart they have to be spaced to cease to convey sufficient vertical information.

Worked out in a simple formula, but only as a basis for further discussion, let us assume that contours drawn closer than 25 to an inch are wasteful, and that in very steep terrain fewer than 15 contours per inch do not provide sufficient information. With this assumption, then, excluding escarpments, cliffs, and the like, we can start with our normal steepest terrain which is probably a 1 to 2 slope; that is, where the ground rises 1 foot in 2 feet of horizontal distance. A 50-foot interval then, where the rise is 1,000 feet in 2,000 feet horizontally, will give us 20 contours per inch on the map. So, if our area to be mapped contains 1 to 2 slopes in any quantity, our interval should be 50 feet. This would, for the most part, obviate the necessity of dropping

contours in steeper areas on our map. Supplemental contours in the less steep areas would ordinarily provide sufficient information, but these should be shown only where the supplemental contours portray differences in elevation that a direct interpolation of the contours would not indicate. Or, let us say, supplemental contours might be shown where the space between our 50-foot contours is greater than ½ inch on the map. Forty-foot contours might be used where a slope of 800 feet in 2,000 is quite prevalent in our map area, and supplemental 10- or 20-foot intervals might be used in the lower, flat areas where the 40-foot contours are spaced wider than ½ inch.

Twenty-foot contours might be used where a slope of 400 feet in 2,000 feet is prevalent, supplemented by 10-foot contours where the spacing of our 20-foot contours is more than ½ inch. Ten-foot contours might be used where the slope is 200 feet in 2,000, and 5-foot contours where the slope is less than 100 feet in 2,000 feet. All these relations of interval to slope provide approximately 20 contours per inch for the steeper terrain.

A summary of these relations in tabulated form follows (all values are in feet).

Slope	*Interval*	*Supplemental*
1,000 in 2,000	50	25
800 in 2,000	40	20
400 in 2,000	20	10
200 in 2,000	10	5
100 in 2,000	5	2½

This seems to be a start toward the solution of the problem of selecting appropriate contour intervals, wrapped up in a neat little formula, so far as the standard quadrangle series is concerned. I offer it to this panel and to the Congress for further consideration.

These proposed solutions, however, do not solve Mr. Eliel's problem. His is a special problem to be solved by the selection of a map scale, a vertical interval, and a specified accuracy, all based on the requirements of a special-purpose map. Mr. Eliel must solve every special mapping project according to its own requirements and he is obliged to keep costs at a minimum. He knows what special requirements his map must fill, but no one here today can predict what uses a standard quadrangle will have tomorrow.

Scale, Contour Interval, and Accuracy of Topographic Maps

By ROBERT H. LYDDAN
U. S. GEOLOGICAL SURVEY

FIRST, I'd like to emphasize the word *practical* used by Mr. Eliel in starting his paper. We are discussing things here that directly and greatly affect the cost of the map on the one hand, and the usefulness of the map on the other. If the decisions as to the scale, contour interval, and accuracy selected for any mapping job will not stand as a *practical* solution from both standpoints, then it is no solution at all.

The uses to which maps can and are put are almost unlimited, and in no two instances are the requirements exactly the same. Therefore, fixed rules cannot be formulated by which scale, contour interval, and accuracy can be selected to suit a given mapping project best, other than a few simple practices such as making the scale conform, where feasible, to some recognizable relation of inches to feet or inches to miles, or making the contour interval a fraction or multiple of some even number for the sake of simplicity.

Messrs. Eliel, Woodward, and DaSantos have directed their comments primarily toward special-purpose maps. I believe that at one time it was intended that this panel restrict itself to special maps—excluding the general-purpose maps such as those published by the Geological Survey.

When I assumed that, my first reaction was one of relief. Having excluded the only subject on which I might make intelligent comments, I thought that probably I could just tell a funny story and then pass the mike to the next speaker. Mr. Griffith didn't like the idea, however, and got Mr. Eliel to expand the topic to include general-purpose maps, so that put me back on the hook. Seriously, these problems are very important and interesting from the viewpoint of the general-purpose-map maker and I would like to urge anyone who has any new ideas on the subject to let us have them. We can always stand some fresh and intelligent thinking on these matters.

USE OF SUPPLEMENTAL CONTOURS

One of the things that complicates the selection of appropriate contour intervals is that the nature of the terrain does not always remain the same throughout the area to be mapped. In some parts the slopes may be steep, and in others they are gentle; and the contour interval appropriate for the gentle slopes is not appropriate for the steep slopes that fall within the same map or within the same project. This situation suggests the use of supplemental contours to show the detail in the flat areas, omitting them where the slopes are steep enough so that a larger interval will suffice.

During the last 5 years the Geological Survey has greatly extended the use of supplemental contours. They show detail where it is needed and avoid cluttering the map with many unnecessary and unreadable contours where the slopes are steep, and money is saved in the process. I should think this principle could be applied more extensively to special-purpose maps.

Supplemental contours usually have an interval half that of the regular contours on the map. However, the interval may be a quarter of the regular interval or any other fraction that is suitable. The accuracy with which the supplemental contours are drawn is usually in keeping with the smaller contour interval. Unfortunately, the use of what amounts to two contour intervals on a map is not completely reconcilable with the most economical photogrammetric procedures. Two sets of photography may be required and the limits of the area requiring photography from a lower altitude may be difficult to determine in advance. This can be avoided, in some instances, if the same set of photographs is used in two photogrammetric instruments having different C factors, such as the Multiplex and the Kelsh Plotter.

RELATION OF GROUND SLOPE TO VERTICAL ACCURACY

Getting away from the supplemental contours now, and thinking of maps in which only one contour interval is used, I am sure that many of us have debated the question of whether the accuracy with which the contours are drawn should be the same on the steep slopes as it is in the flatter areas. In quadrangles mapped by planetable by the Geological Survey in years gone by, the ridge tops and valley bottoms which were traversed by the topographer were usually more accurately contoured than were the steep hillsides which he didn't traverse. That practice kept the cost of the map down and, at least in the minds of some map users, was in line with their requirements.

I recently learned of a recommendation in a text that was partly translated from German to English not long ago. It suggests a formula for determining the vertical accuracy with which the contours must be plotted, and takes into account the idea that, although the contour interval remains the same throughout the map, greater accuracy may be desired in the flat areas and less accuracy needed where the slopes are steep. The formula gives the allowable vertical error as a constant (a) plus another constant (b) multiplied by the tangent of the slope of the ground. Where the ground is quite flat the second half of the formula is virtually zero, so the allowable error consists of constant a.

Let's picture the application of that formula to a special-purpose map made in connection with an irrigation study and with a contour interval of 5 feet. In the flat areas, which will probably eventually be

irrigated, it might be desirable to hold the contours within a 2-foot vertical tolerance. Constant *a* should, therefore, be 2. Constant *b* might be selected so that, at the outer limits of the irrigable area where the steepness of the slopes would preclude irrigation of the land, the second element of the formula would be about 3, thus giving a full contour interval as the allowable error. So far as I know this formula is not used in this country.[1] It seems to me to have some very practical applications in those instances where the value of the project or likelihood of development is greatest in areas where the land is flattest.

PATTERNS OF CONTOUR INTERVAL AND ACCURACY

Now let us consider more generally the contour-interval problem as we face it in the Geological Survey. Our early work in the Eastern States was mostly done using the 5-, 10-, 20-, and 40-foot contour series. The transitions from one type of terrain to another were gradual in most areas, so it was logical to double or halve the contour interval when a change to another interval was necessary. On the Pacific coast, however, steep rugged mountains often changed abruptly to very flat plains, such as the Central Valley in California. There the 5-, 25-, 50-, and 100-foot contour series was put to use when that work was started many years ago.

The evil day of reconciling those two systems into one that could be used throughout the United States was put off for a long time. We are now trying to work out a general pattern that will reduce the conflicts and confusion as much as possible.

Before closing I'd like to comment briefly on the need for uniform accuracy in connection with general-purpose maps. Admittedly, the determination of what accuracy is needed is a very difficult problem, because of the variety of uses to which the map will be put. It is, nevertheless, important that there be a standard of accuracy so that adjacent maps in the same series will be uniform; and so that the map user can know what minimum accuracy he can expect; and so that the job of revising the maps and keeping them up-to-date can be simplified and expedited.

I'll stop here, although I have only scratched the surface of these problems as we see them in the Geological Survey. Certain chapters in the new technical manual that we are now writing will cover these problems in considerable detail. Some of you may be interested in pursuing the matter further when the manual becomes available.

The objective of each of us engaged in map-making should be to make each map adequate for the purpose intended, at the lowest possible cost. Whenever we do that we have found the *practical* answer to the problems of scale, contour interval, and accuracy.

[1] In the interval since the preparation of this paper, the Geological Survey has undertaken an investigation of European vertical-accuracy standards as compared to American standards. British specifications, which are based on a formula in which the allowable vertical error is a function of the ground slope, have already been studied and compared with American specifications. It must be remembered that the horizontal shift of 1/50 inch (40 feet at 1:24,000 scale) allowed in American specifications also has an effect on vertical tolerance. As the ground slope increases, the vertical tolerance is, in effect, increased by an amount equal to the allowable horizontal shift times the tangent of the angle of slope. The Geological Survey's comparison of British and American tolerances indicates that, although the American specification allows somewhat more vertical tolerance than the British, the changes in tolerances as the ground slope increases are comparable in their general trend. A report on this investigation will be available in the near future—Ed.

DISCUSSION

MR. QUINN: We have come to the conclusion of the formal part of this particular program. I note with some horror that it is just about five o'clock. However, some of you may wish to question this group of experts and I certainly recommend that you take advantage of their presence.

Please address your questions to a specific

member of the panel or, if it is a general question, address me and we will try and get one of the gentlemen to answer the question for you.

MR. SKOP: I don't have a direct question. I have listened with great interest to the panel members. I was very much impressed with their opinions and ideas, and what impressed me most was their attitude toward practicability. Now, I don't see why you don't stop talking about it and apply it as far as topographic maps in the United States are concerned. The situation, as you all have heard several times today, is that only about 25 percent of the United States is adequately mapped. It will be a good many years, even with all the applied effort, before it will be completed.

I think we ought to apply some of this practicability, and in certain areas, or as much as possible, drop a bit of the accuracy requirements in order to get the country mapped as fast as possible. We should have learned our lesson from the last war, when we didn't have enough maps. I think if we all concentrated on the task, applying some of this practicability we are talking about, we could get the country mapped much quicker than we are doing now. In other words, I am advocating possibly a little bit lower quality and a greater use of a larger contour interval. I think that way we will get the work done faster and let the next generation of FitzGeralds and Ladds bring the maps up to more accurate standards.

MR. QUINN: Thank you, Mr. Skop. Mr. Lyddan, do you care to make any remarks on that particular subject?

MR. LYDDAN: That is a serious problem, whether to move along more rapidly with maps of lower quality which will obviously be obsolete at an earlier date, whenever that may be, or to proceed more slowly, producing maps of higher accuracy suitable for publication at larger scales. I can point to instances where, after giving considerable independent thought to this question, opposite conclusions have been reached. In Illinois and Indiana, for example, the topography and economic problems are quite similar, but one State has insisted that its map needs will be better met by concentrating first on a program of 15-minute quadrangle mapping, although the other State has even more firmly insisted on a 7½-minute quadrangle program. I think that opinion on the subject will never be unanimous; it is a question of reconciling the various viewpoints insofar as possible.

MR. FITZGERALD: It is the most serious problem we face in formulating a national program. If we had time to make a thorough study to determine the perfect publication scale and contour interval, we could probably do a better job. At the pace we are moving now, that is nearly impossible. We often find that we have selected a contour interval, and sometimes a scale, that seems to be adequate for the greatest number of map users, but there are one or two map users whose need for the maps could probably outweigh the need of all the others. In many instances the one or two map users require a larger scale and a smaller contour interval.

In several instances we have had to go back, either to map supplemental contours, or to re-map the sheet at smaller contour intervals. We have, however, made a start in one State, Indiana, by enlisting the aid of the map users in a study of contour intervals. That study was completed several months ago. It was made by a team of Geological Survey men and State representatives, the map users. We believe that, if we were consistently able to do that ahead of our mapping program, we would come out with better answers. I believe that the procedure of selecting a very large contour interval and sweeping the country at a general scale with a generalized map would be uneconomical because we would have to go back before we had completed any part of that program and re-map at a larger scale with a different contour interval.

MR. QUINN: Thank you, Mr. FitzGerald. I am sorry that it is necessary to curtail further discussion on these problems. Unfortunately our allotted time is up.

To summarize briefly, I think that our panel experts have prepared most interesting and informative papers about a most important problem. The mapper, whether he is thinking of country-wide mapping or of individual commercial mapping, is constantly trying to supply the best possible maps to meet the immediate needs. In many cases, the map user needs to be shown how to make good use of the maps which are prepared, and certainly we need to continue close liaison between map makers and map users. The ideas presented here today should give us all a lot to think about, and I recommend that further discussions on this subject be continued in SURVEYING AND MAPPING, and at our next meeting.

Maps for Defense

By COL. JOHN G. LADD
COMMANDING OFFICER, ARMY MAP SERVICE

MAPS for the defense of Europe! A tremendous number of copies of over 10,000 different maps were, and are, required for this purpose. That's quite a lot of maps for which to draft grid plates, photograph drawings, print adequate stocks, and then distribute—all in less than a year. As far as I know, it constitutes the largest project in the history of military mapping. This tremendous job has been just recently completed. By redoubling our efforts, the Army Map Service was able to contribute the major share of the work to the project and at the same time not jeopardize its heavy commitments for the Korean conflict and the numerous other Department of Defense mapping requirements.

The particular huge quantities of replacement maps of which I speak cover a very large part of Europe and were prepared as a cooperative mapping program. In addition to the efforts of the Army Map Service, the project engaged practically the entire map-making capacities and facilities of the military mapping agencies of France, Belgium, Great Britain, The Netherlands, and Italy, in addition to the mapping units of the French, British, and American Forces in Germany. The excellent spirit of cooperation which prevailed among these organizations throughout the project assured its ultimate success and further proved that the teamwork of democratic nations is *fact* and not idle *speculation*.

But what was behind this tremendous mapping effort? Why all the haste to produce all these vast quantities of maps? The uninitiated would think that from the millions of maps produced during World War II surely enough should still be on hand to satisfy present military needs. To find the answers, we must look back at the mapping situation in Europe over the past 10 years or so.

Throughout World War II, adequate numbers of maps were generally available to the Allied Forces in Europe. Of course, these didn't exist at the beginning of the war. They resulted from the coordinated efforts of the British and Americans, with the British Directorate of Military Survey and the U. S. Army Map Service sharing the bulk of the load. As a matter of fact, the unprecedented number of maps which were supplied made mapping history. Just to give you an idea, the Army Map Service alone, during World War II, published 500 *million* copies of over 30,000 different maps.

With the end of World War II, huge stocks of maps of Europe at all scales were on hand in the various military depots. And at the end of the war, the peoples of the world desired, and deserved, peace. We relaxed. The production of additional maps slowed down almost to a standstill. The peace and the rapid withdrawal of troops from Europe could not help but create a confusion in which the possible need for maps in the future was almost completely disregarded. Map stocks were declared surplus and commercial firms either ground them into pulp or made envelopes and scratch pads out of them. Thus, in a very short time the military stocks of most maps dwindled to a point perhaps even below the prewar low.

Prior to World War II, excellent maps of native origin existed for large areas of Europe; these included coverage for The Netherlands, Denmark, and critical areas of France. Unfortunately, very little of the reproduction material or even copies of these maps were held by the British or Americans. When war broke out, the Nazis swarmed over Europe so

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rapidly that it was impossible to get these materials out of continental Europe. Consequently, the use of these maps was denied to the Allied Forces throughout World War II and the maps used instead were, at best, only tolerable substitutes, being made from outdated base maps and combat aerial photography.

An important adjunct to a military map is its surprinted military grid. A grid consists of two sets of equal-spaced parallel lines mutually perpendicular to each other, forming a pattern of squares. On large-scale maps the lines are usually at 1,000-meter intervals. These lines are consecutively numbered from south to north and from west to east with the point of origin being arbitrarily selected somewhere to the southwest of the area covered by the grid. A military grid serves a dual purpose—it greatly enhances the firing accuracy of artillery for it facilitates the ready computation of range and direction; and it is used to give a simple numerical identification—the grid coordinates—of any point on the map.

Throughout World War II, the Allied Forces in Europe used what were commonly called "British Grids." This system was made up of a number of heterogeneous grids, many of which were adopted and adapted European national grids. They differed in characteristics, projection, spheroid, and layout. Although many knotty problems were encountered in military operations in moving from one grid to another, these grids, however inadequate, were made to serve their purpose during World War II.

After the end of the war, it was realized that military tactical evolution required a uniform grid system for the world. The old grids were inadequate for coordinated military operations covering large areas. Under the direction of the Chief of Engineers, the Army Map Service developed such a grid—the Universal Transverse Mercator Grid. For brevity, this is usually referred to as the UTM Grid.

Modern map making has its deepest roots in Europe. The national maps of the various European countries were started back in the 1700's and early 1800's. However, each country went its own way and little if any coordination existed. Each country established its own national system of horizontal control, usually based on a different origin and on a different spheroid from those used by its neighbors. The result was that along international boundaries a common point appearing on the two different national maps would have different geographic coordinates. Gaps and overlaps in horizontal control existed along all boundaries. This situation had never been remedied and proved very awkward to the artillery during World War II. At the end of the war, it was realized that such a situation was critical, especially in the firing of long-range projectiles. The condition was remedied after the war when the Army Map Service, with the good will of the European nations and with the geodetic data supplied by them, computed adjustments and fitted the differing national systems into a single homogeneous European datum.

Within a few years after the war's end, it became apparent that the rapid military demobilization, especially in Europe, was a mistake. To remedy this error, the democratic nations of Europe and the United States banded together and undertook various measures for their mutual defense. Important among these was standardization of weapons and equipment. One of the ramifications of this program was maps and related items. After studying the situation, it became apparent that five primary problems existed:

(1) The preparation and depoting of stocks of maps sufficient to satisfy the defense plans agreed upon by higher headquarters;

(2) The replacement of wartime emergency maps with now-available more accurate maps;

(3) The use of a common European horizontal datum for all the maps, regardless of national origin;

(4) The need for the adoption and applica-

tion of a standard military grid and referencing system; and

(5) The establishment of a firm, realistic date for the accomplishment of all this work.

The several nations had already approved the common European datum in principle. All that remained was to find a feasible way of adjusting the maps to this datum. It was agreed that it would be impossible within the short time at hand to recast map-sheet lines. The solution agreed upon was simple—the geographic coordinates of the map corners would be replaced with new coordinates, expressed in decimal values, based on the common datum.

As an answer to the grid problem, the UTM grid and the complementary Military Grid Reference System were suggested. These were adopted.

Now, all that remained to be done was the big task—the preparation of adequate UTM replacement stocks of the best available maps. This task entailed drafting the grids for over 10,000 different maps, photographing the drawings, making press plates, printing sufficient quantities for the initial defense of Europe, and shipping, depoting, and distributing the maps to the troops who needed them. And not much time was available to accomplish this Herculean task.

The representatives of the national mapping agencies and armies concerned sat down together at various conference tables and worked out the details of what had to be done and who was to do just what. They divided the responsibility, with each nation taking a share of work proportional to its capabilities. It was arranged for the nations having the largest facilities to give assistance—both physical and with critically short materials—to the others in order to ensure completion of the task within a reasonably safe time.

A realistic date for completion was established. This took into account that all the maps had to be in European depots at least 4 to 6 weeks prior to what was called "C-Day;" that a distribution of these maps had to be made all through the line—from the highest headquarters on down to the soldier who had to use them—all this prior to the date of conversion; and that arrangements had to be made to have all the maps which would become obsolete, on issue of the new ones, turned in just prior to the date of conversion.

Besides the maps, trig lists had to be printed in book form. This entailed the conversion of the trig points from the old datums to the common adjusted European datum and in terms of the UTM grid. Fortunately, the Army Map Service had electronic computing machines available, otherwise the completion of this particular phase would still be in the far distant future. All told, 450,000 copies of over 1,500 trig books were printed. These included over 420,000 points, the majority of which had accompanying detailed descriptive sketches to aid the user in locating the points in the field.

I am glad to report that the job has been done and it was done on time. The logistics problems were often knotty, but never without solution. In preparing our share of these many replacement maps, the Army Map Service alone used nearly 3,000 tons of paper. The Army Map Service printing presses were geared-up to a two-shift basis. Even this was not enough and it was necessary to contract for the printing facilities of more than 40 different commercial lithographic firms. As for the drafting, the hundreds of draftsmen at the Army Map Service and its five field offices, although they redoubled their efforts, could not do all the work. Assistance was secured from the Lake Survey and the Tennessee Valley Authority. An auxiliary Army Map Service unit in Frankfurt, Germany, also contributed to the work. And to assure completion on time, drafting contracts were let to about 15 different commercial drafting firms.

But maps and trig lists were not all. In addition, 5 sets of duplicate reproduction material of each of the 10,000 sepa-

rate maps had to be made and shipped to the recipients. Inasmuch as the maps averaged four colors, this meant that approximately 200 *thousand* sheets of film had to be printed, processed, assembled, and shipped to destination. The shipping of these 3,000-odd tons of maps, these 200 thousand-odd sheets of film of reproduction material, and these 450,000-odd booklets of trig data was a formidable task in itself. Each item had to be sorted, assembled for shipment, packed according to strict military regulations, placed on trucks, moved to trains and planes and ships, sent overseas, unloaded, and reloaded on trains and trucks to finally reach their points of destination, where again, they had to be unpacked, sorted, placed in bins, reassembled, and then finally distributed to the NATO troops. It is remarkable that with all this handling, everything went smoothly and no shipments were lost. Every shipment reached its destination before the date set.

Yes—it was a big job, but it was done and it was done on time. And what is of great importance, in this present world of doubt and unrest, it was done by all the nations working *together* as a *team*. And what is of immediate importance is that initial stocks of maps with the new UTM grid are now safely on hand for the defense of Western Europe, thanks to the untiring efforts of these map makers; even though a considerable amount of revision work is still necessary to bring many hundreds of these individual map sheets up-to-date.

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Shoran Operations in Canada

By J. E. R. ROSS

DOMINION GEODESIST, DEPARTMENT OF MINES AND TECHNICAL SURVEYS, OTTAWA

CANADIAN operations with shoran as applied to surveying and mapping may be regarded as having begun in 1947. During the next two winters experiments were conducted in the vicinity of Ottawa to assess the accuracy of shoran positioning in comparison with that obtained by first-order triangulation. The results were encouraging enough to warrant consideration of shoran as a means of establishing position in Canada's vast northland. First, it had to be demonstrated that a shoran net of considerable length, starting at a base derived from the first-order triangulation, could give an acceptable closure when carried over the intervening distance to another geodetic base. In 1949 and 1950 such a shoran net of 1,100 miles in axial length between geodetic bases was completed in Manitoba and Saskatchewan, with results which indicated that shoran, with all details carefully supervised, could produce results with an accuracy superior to astronomic positions. This is the only reasonable alternative method of control at the present stage of development of the northern areas. More than 800 geographic positions have been determined in the last 10 years by the exploratory astronomic method. These have been satisfactory for control in the production of small-scale maps where displacements of as much as 400 feet are not plottable. Such astronomic determinations are not sufficiently accurate to use as control for the large-scale mapping which is essential and in demand now by the various agencies concerned in the development of oil and ore potentials, not only in local and relatively small areas but in regions of vast extent.

In the seasons of 1949, 1950, and 1951 the shoran net has been advanced from the 49th parallel in southern Manitoba, northwestward through the provinces of Manitoba and Saskatchewan, and northward down the Mackenzie River basin to the Arctic coast in latitude 70°, over an axial length of 2,500 miles. In this net 40 shoran stations have been established, and the 149 lines between stations, averaging 210 miles in length and forming the geometrical pattern of the net, each have been measured 16 times. In addition, 13 stations have been prepared in a 1,200 mile belt extending from Great Bear Lake eastward to Hudson Strait. These 13 stations form the basis of a shoran net of 46 lines which will be measured in 1952.

TRIANGULATION CONTROL IN NORTHERN AREAS

The existing high-order triangulation control is largely confined to the settled area which extends from coast to coast along the southern part of Canada. There is also a continuous arc of triangulation along the Pacific coast to Skagway, thence to Whitehorse, Yukon Territory, and thence westward astride the Alaska Highway to the 141st meridian and also eastward to the vicinity of Fort Nelson, in the northeast part of British Columbia. In addition, there is minor triangulation control along the 141st meridian (the Alaska-Yukon boundary) and from Seven Islands, Quebec, northward to Ungava Bay, this latter net lying some 2,500 miles east of the former. The northern areas east of the Rocky Mountains thus lack accurate control in the form of either triangulation or levelling. In this vast region astronomic positions have provided what horizontal control we have. With the recent introduction of electronic methods of distance measurement, the use of astronomic positions for mapping control will decrease. Economic development has demanded better maps and, as time is a factor, electronic methods

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GREENLAND
ATLANTIC OCEAN
Gulf of St. Lawrence
PROJECT
QUEBEC
1953-54
PROPOSED
Hudson Strait
Ungava Bay
Baffin Island
Hudson Bay
ONTARIO
1952 PROJECT
MANITOBA
1949-50-51
SASKATCHEWAN
COMPLETED
ALBERTA
Great Bear Lake
Mackenzie River
ARCTIC OCEAN
YUKON
BRITISH COLUMBIA
ALASKA
PACIFIC OCEAN
CANADA
SHORAN OPERATIONS
Geodetic Base
Statute Miles
100 0 100 200 300 400 500
50
80
110
140
170

of establishing control furnish the answer with both speed and accuracy.

BASIC OPERATIONS

The operations involved in a shoran-geodetic survey are not only extensive but complicated, and require the facilities and cooperation of many organizations. A reconnaissance is made by air and then by ground to select antenna sites of sufficient height to provide straight-line clearance of ray paths to the plane engaged in line measurement. For ease in transport these sites should be close to fairly large, deep lakes with good landing beaches, thus reducing the lengths of trails and providing safety for the supply planes. Each site is permanently marked by a monument or tablet, and in wooded areas a surrounding area 100 feet square is cleared. In the more northern interior regions basic elevations are nonexistent. It is thus necessary to determine the elevations of lake surfaces by barometric procedures during a period of 14 days with readings of wet-and-dry bulbs and barometer being taken every 3 hours at specified times to allow correlation of the data with weather information of the Meteorological Service. The elevation of each antenna site is obtained by spirit levelling from the lake surface. Radar altimetry would be of great assistance in this connection and it would also provide numerous spot elevations, but at present it is not in use. The approximate position of each antenna site is determined by astronomic observations. The azimuth is also calculated and marked on the ground for the antenna orientation. From these data, the navigator on line-crossing measurements is provided with information as to the approximate length and direction of each radiating line. Subsequent comparison of the astronomic position and the shoran position of each station gives an approximate indication of the deflection of the vertical at that station.

An extensive organization is required to perform these operations and the work has been done as a cooperative venture by personnel of the Royal Canadian Air Force, National Research Council, Meteorological Service, and the Geodetic Survey of Canada. When it is realized that the field season lasts only about 3 months owing to lakes not being free from ice more than 4 months in the lower latitudes and progressively less as one approaches higher latitudes, one gains an appreciation of the necessity of personnel being highly trained in order to take full advantage of the short period of operation. The transportation of equipment and some 160 personnel 2,500 miles by air, the provision of food and shelter for them, the maintenance and operation of the antenna stations, and the servicing and operation of both line-measuring and supporting aircraft, coupled with the need for a high order of accuracy in the work, tend to make the operation a challenge to all concerned.

SHORAN PROJECT

It is expected that the shoran operations south of latitude 66°, with a few extensions reaching to latitude 70°, will have an axial length of about 5,500 miles and will form a huge arc with connections to five geodetic bases available from the existing first-order triangulation. In three seasons we have now completed 2,500 miles of this arc, and from past experience it appears feasible to complete the rest of the arc in three more seasons to a junction with first-order triangulation in the East, on the north shore of the Gulf of St. Lawrence. The shoran trilateration is necessarily the first step, but auxiliary stations will have to be established in any area for supplemental use in controlling the aerial photography. The principal shoran lines in general are too long to serve as the sole control for aerial photography because signal reception in these circumstances is not feasible when farther than 150 miles from an antenna, and in many areas the sites are not properly placed to secure favourable intersection of position.

In geodetic surveying and mapping the sea-level distance between stations is required; therefore, it is necessary to consider shoran trilateration sufficiently strong in a geometrical sense to give not only length to a certain accuracy but at the same time to give position to a relatively high degree of

accuracy. Conventional triangulation requires the measurement of angles and, for a quadrilateral in which all angles are measured, four geometrical conditions must be satisfied. In trilateration the measurement of the six lines of a quadrilateral imposes only one condition and hence there is a decrease in the strength inherent in the method. To offset this, stations should be arranged in pentagon pattern so that extra lines of measurable length may be introduced from stations in one figure to stations in adjacent figures, thus giving overlap. We have endeavored to provide a standard of two more lines per station than are required to fix the station. There are practical limitations as to the maximum operating altitude of the line-crossing plane and to the distance at which the signals, due to lack of strength, may be received from the ground stations. With our present equipment these limits are 20,000 feet in altitude and some 165 miles in length. Thus the maximum length of measurement is approximately 330 miles.

LINE CROSSING AND LENGTH MEASUREMENT

The shoran instrument in the plane flying at uniform ground speed, height, and direction, in the vicinity of the center of the line, emits pulses (20 per second) which are alternately sent to the terminal ground stations on frequencies of 230 and 250 megacycles and are then delayed a fixed amount and returned on a common frequency of 300 megacycles. The elapsed time between emission and reception is registered on mileage dials which, together with other dials, are photographed at 3-second intervals. It is evident that the true sum of the distances, plane to stations, is greater on each side of the actual crossing and is a minimum at the crossing. If time is plotted against sum, the plot approximates a parabola and a mathematical curve of best fit will determine the minimum sum distance corresponding to each line-crossing flight.

All lines of the project have been measured by a minimum of 16 line-crossings, of which 2 groups of 8 each were measured on different days to ensure a change of atmospheric and other conditions and to reveal unstable equipment.

As an example, let us now consider the results obtained for the line Fort Simpson—Peace (*see* tables 1 and 2). This is the longest line so far measured in our operation.

In table 1 the values of the 16 line-crossings reduced to sea level are given, and it may be seen that the means for the two flights agree within 21.6 feet. With reference to table 3 we see that an agreement within this range is obtained 50 percent of the time. The spread in each group of four is 40, 20, 84, and 25 feet, which reflects not only operator and other errors but also the elimination of certain instrumental errors due to the figure 8 line-crossing pattern. The agreement of the means for the 2-day operation is representative of the work in

TABLE 1

Line: Fort Simpson—Peace

Indicator 1405 Aircraft 212 Recorder 2

June 30/51		Date	July 3/51	
20,000 feet		Flight height	20,000 feet	
329.5860 miles	329.5881 miles		329.5956 miles	329.5892 miles
.5795	.5884		.5841	.5847
.5853	.5850		.5924	.5856
.5876	.5889		.6008	.5898
329.5846 miles	329.5876 miles	Average of 4	329.5932 miles	329.5873 miles
329.5861 miles		Average for day	329.5902 miles	

Grand mean, reduced length: 329.5881 miles

TABLE 2.—*Corrections to shoran measurements for first crossing of table 1*

Base value of computation		330.1500 miles		
Minimum of curve above base		.0071		
Minimum shoran distance ($R+D$)		330.1571 miles		
Minimum rate and drift station distance	165.8550 miles		164.3021 miles	
	Rate		*Drift*	
Corrected altitude of plane (H)	20,317 feet		20,317 feet	
Antenna altitude (K)	619 feet		2,376 feet	
Slope distance (R and D)	165.8550 miles		164.3021 miles	
Delay	− .1669		− .1908	
Velocity	+ .0082		+ .0082	
Frequency	− .0006		− .0007	
Indicator 1405	− .0015		− .0015	
Slope distance (corrected)	165.6942		164.1173	
To sea level	− .0827		− .0888	
For slope	− .0420		− .0352	
For curvature	+ .0116		+ .0116	
	165.5811 miles		164.0049 miles	
Reduced length (table 1)		329.5860 miles		
Grand mean (16 crossings) (table 1)		329.58810 miles		
Calibration constant		− .00446		
Correction from adjustment (v)		− .01336		
Adjusted length (1951 net)		329.57028 miles		

TABLE 3.—*1949–50–51 operations*

Range (feet)	0–10	10–20	20–30	30–40	40–50	50–60	60–70	70–80
Number of lines	42	29	28	18	15	8	4	3
Percentage of lines	28.6	19.7	19.0	12.2	10.2	5.4	2.7	2.2
Cumulative percentage	28.6	48.3	67.3	79.5	89.7	95.1	97.8	100.0

general and indicates good control of all factors insofar as they can be controlled. The variation in measurement from day to day is beyond control and the grand mean may thus be expected to contribute more highly to general accuracy than agreement of readings on any one day. No measurements of the intensity were taken but all flights were made at that altitude where the incoming pulses were most intense and least distorted. It is stressed that the consistency of values obtained for any one line in one day's operation of 8 line-crossings is an indication of relative accuracy but no clue is given of the extent of systematic error or of the effect of other conditions peculiar to the day's operation.

In table 2 the corrections to the shoran measurement, which lead to the value 329.5860 in table 1, are tabulated to indicate the relative size and sign of the various corrections needed to reduce the measured values, plane to stations, to the sea-level length from station to station. In the reduction, use is made of the best values obtainable for H, K, and the delay, but they are suspect to various degrees and this contributes to inaccuracy. Because levelling control is nonexistent, the antenna altitudes are determined by barometer, but they are believed to be accurate to within 25 feet on the average. The height of the plane, under certain atmospheric conditions, may be in error by at least 125 feet, which will cause an error in length of some 15 feet. Because of calibration difficulties, the delay has been determined on a relative rather than on an absolute basis. Anderson's velocity of radio propagation is used, and a calibration constant is derived in the adjustment to cause the shoran net to fit between triangulation bases. If the work is done uniformly, the

net effect is a change in scale, thus taking care of both calibration and velocity difficulties which, unfortunately, we are not able to separate. The calibration constant and correction from the adjustment here indicated are obtained from the connection of the shoran net to two geodetic points belonging to a loop not yet closed and thus subject to revision. Nevertheless, the accidental error of −0.01336 mile, or 70.5 feet, the third highest in the operations, indicates an apparent accuracy of 1 in 24,670. Inasmuch as the line is the longest measured and no intensity measurements have been made, it is likely that a falling-off of intensity relative to that for an average line (210 miles) has occurred, and the relatively large minus correction to the observed value is supported on these grounds. For the 149 lines the average correction without regard to sign is 19.4 feet.

Table 3 has been compiled to illustrate the number of lines for which the means obtained on separate days fall in groups of 10-feet difference. Thus for 29 lines (19.7 percent) the means were not greater than 20 feet nor less than 10 feet apart. It may be inferred that 50 percent of the line measurements on separate days are in agreement within 20 feet and 75 percent within 35 feet for the entire operation. The remaining 25 percent are largely contained within the range 35 to 60 feet. Only occasionally are values beyond 80 feet obtained, and when this happens an overhaul of electronic equipment is immediately indicated.

FIELD ANALYSIS

A geodetic unit of 8 to 10 men, recently including a meteorologist, has been attached to the operation to compute the data and make the reductions immediately after the line-crossings. With a limited number of ground installations this has distinct advantages, as small adjustments can be made and information can be gained at once as to whether additional flights are necessary over certain lines.

The data were prepared for each unit set-up of ground equipment as the work progressed, and no movement of equipment was authorized until some 20 lines had been adjusted to check the over-all consistency of the measurements in forming geometrical patterns. If relatively large corrections were required for certain lines, this indicated that these lines needed to be remeasured to get better accuracy. Additional flights have invariably confirmed the conclusion based on the adjustment.

ACCURACY

A pertinent question is "What accuracy is being obtained?" To answer this we must first rephrase the question so it reads "What accuracy do we believe is being obtained?" for as yet we have no interior checks on position. The general picture may, however, be gathered from the results obtained in the first net of 74 lines, extended 1,100 axial miles between geodetic bases. This is summarized briefly as follows:

(*a*) Lines of average length, 210 miles, may be measured to give a mean accidental error of 18 feet.

(*b*) In a network in which there are twice as many surplus lines as stations to be fixed, the probable errors in latitude and longitude are about 25 feet.

(*c*) The closure in position at the geodetic base is better than 1 in 59,000, and this lends support to the belief that the intermediate stations are not likely to have a position error greater than the probable error, say 25 feet.

(*d*) The replacement of astronomic determinations by shoran positioning has thus greatly improved the accuracy of control.

Shoran values of position have indicated areas in the north in which the positional effect of the deflection of the vertical is more than 1,000 feet.

The equipment in use was built during World War II but has been modified to improve its use in surveying. This equipment is gradually being replaced by new airborne and ground equipment, which will, no doubt, contribute to improved accuracy. Automatic gain control to offset variable signal strength has been tried, but so far without success. The attachment to the airborne recorder of an errorscope, by which irregularities in the matching of pulses may be assessed and corrected, is believed to be

of more value in photographic missions than in the line-crossings and to date has not been used. Neither has radar altimetry been used.

Difficulty has been experienced with the calibration of the equipment. Nevertheless, the results so far obtained indicate that the accuracy is more than sufficient for the purpose in mind—that of shoran-controlled photography. The shoran net is not intended to replace ground triangulation in local areas, and future extensions northward of first-order work will make more connections to the shoran net possible and thus improve its general over-all accuracy. It must be admitted that it is difficult to maintain direction over long distances with the present shoran equipment and methods. Four Laplace azimuths have been introduced in the net to offset this tendency toward weakness in direction.

APPLICATION TO MAPPING

The application of the shoran system to mapping depends upon the making of instantaneous length measurements from the airplane which is on a photographic mission to two established shoran ground stations. In wartime bombing operations the system was used as a navigation aid to indicate the on-target and bomb-release position according to previous calculation. The timing unit is airborne and the slope distances from the aircraft to the two ground stations used as a base can be determined from the data. When the position and elevation of each ground station and the height of the aircraft are known, the projected position of each vertical photo may be computed.

The accuracy of these shoran fixes cannot be greater on the average than the capability of the shoran operator in matching the return pips with the marker pip on the oscilloscope screen. In line-crossing this operation is strenuous enough but on photoflights when the aircraft may be on a flight line for 30 minutes or more instead of 5, fatigue may contribute very seriously to inaccuracy. In addition, there is but one value of each of the slope distances—that at the time of photo exposure. Delay values, goniometer errors, and other factors have an effect on scale as well as on direction of the plot, but as a rule it is possible to alter and shift the plot to give a very good placement.

More factors must be considered in planning a shoran-controlled photographic flight than in the case of conventional flight missions. In the latter the spacing of flight-lines and the required overlap do not change for they are governed by the flying height and ground relief. In shoran operations the location of the ground stations with respect to the flight area is very important. The airborne set must always be within the effective range of the ground stations, and for best results the angle subtended at the aircraft by these two points should be between 60 and 120 degrees. The path of the shoran ray may be considered for all practical purposes a "line of sight." In a certain sense this means that the ground station and aircraft must be intervisible for efficient operation. The effective range depends on the flying height, H. The expression, Range = $1.4\sqrt{H}$, gives a fair approximation of its value. Here H is in feet and the range is in miles. All these factors must be considered when preparing the flight-line map.

Tests with shoran-controlled photography in the Ottawa area in winter months have given excellent results, and an effort was made in 1951 to take some photography in the northern areas in conjunction with the line-crossings. Although the weather conditions were average, only a small amount of photography was obtained because of the limited number of ground sets with the necessity of movement immediately after line measurement. In an operation as extensive as ours is, we did not expect to produce more than incidental photography, the main effort being directed to advance the shoran control as far as possible in the limited season.

There is an enormous amount of vertical and oblique photography of the northern areas available now for mapping purposes. Hitherto it has been used for small-scale mapping, but it is available for large-scale mapping as soon as more accurate control is established. Shoran has supplied this

control in the areas so far covered. It is expected that a contract for shoran-controlled photography will be let in 1952 for the aerial photography of an area of 172,000 square miles involving 14,000 lineal miles. Control flight lines over the existing vertical photography will be spaced at intervals of 20 minutes of latitude (23 miles) and 1 degree of longitude (30 miles).

CONCLUSION

A brief description such as outlined above may convey to the reader the extent to which electronics is equipping survey organizations with seven-league boots. Canada, with its northern areas over which the normal methods of control are slow and difficult, offers a wonderful field for the use of electronic methods. Doubts about the accuracy of shoran control have been removed by the results of experience and further lines of improvement are indicated. Shoran has been made to work to our purpose.

As the frontier is being pushed back through air transportation, economic development is accelerated, mapping is claiming more attention, and the modern survey tool—shoran—is making possible the realization of the fondest dream of geodesists and mappers—the dream of being ready with control data and maps previous to engineering developments. We have always pressed for this effective result, but not until recently has it been possible to achieve it.

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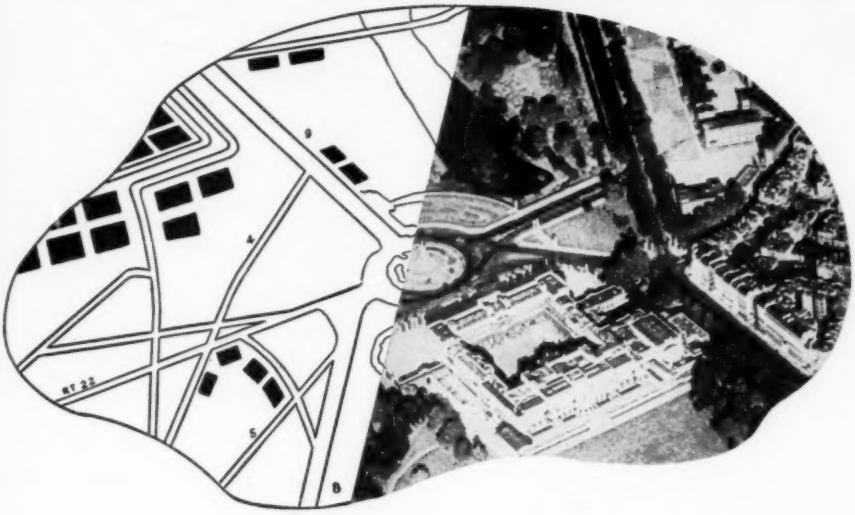

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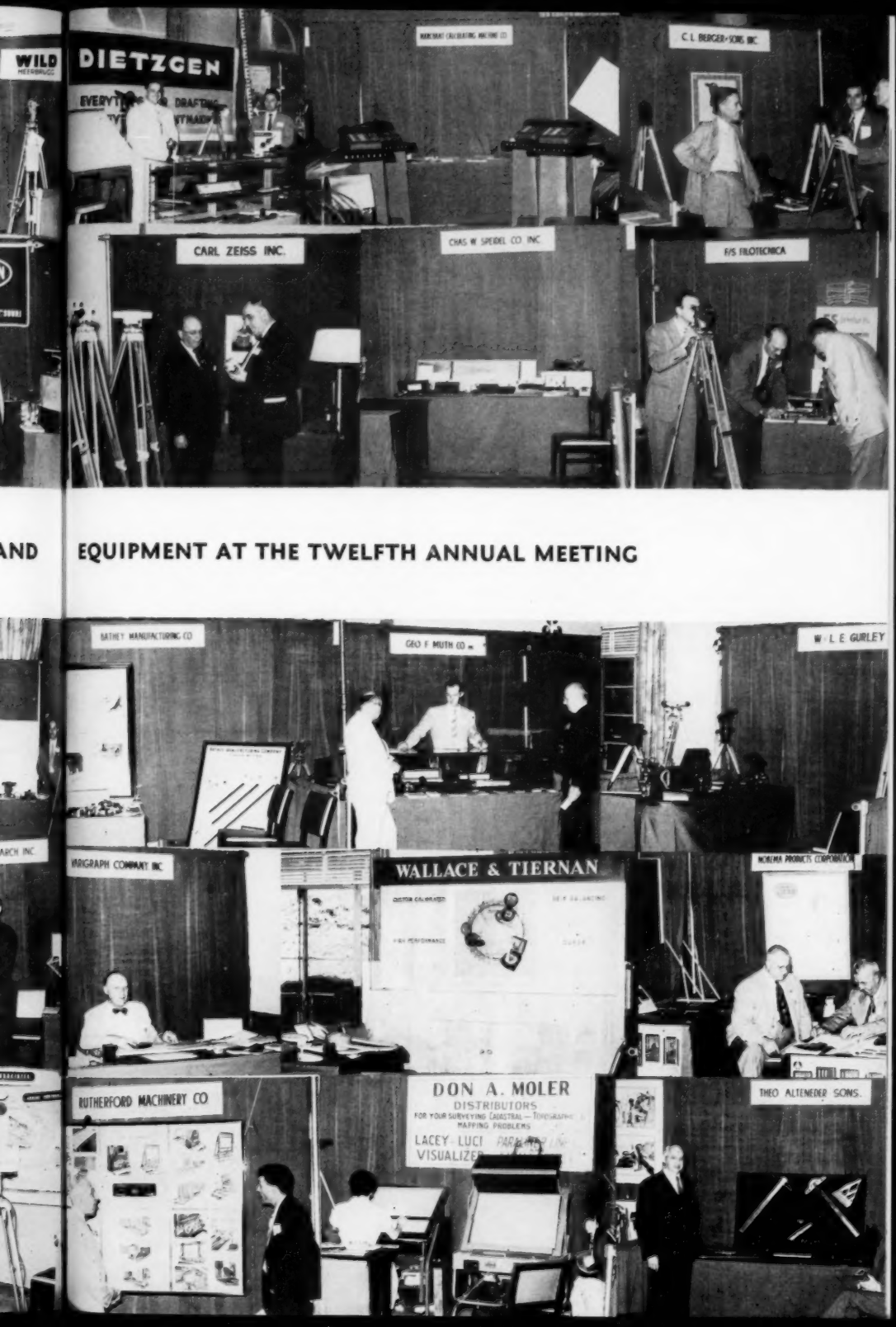


AND

EQUIPMENT AT THE TWELFTH ANNUAL MEETING

Precision and Accuracy

By HUGH C. MITCHELL

PRINCIPAL MATHEMATICIAN, U. S. COAST AND GEODETIC SURVEY, (RETIRED)

IGNORANCE of words does not necessarily indicate the lack of knowledge—except of the words. The unlettered savage may be unable to tell in words how to reach a certain locality or describe what is there; but he may be able to give the desired information by means of a picture or symbol which can be readily understood. As another example, if you ask a local hack driver in a southwestern town to take you to the *depot*, you will get there all right. But if you tell him to take you to the *station*, you will probably miss your train.

Words are peculiar things for, after all, they are merely groups of letters until the spirit gives them meaning. Even then, the peculiarity may persist, for the same assemblage of letters may have various shades of meanings, and various assemblages may have meanings very near the same.

The Federal Board of Surveys and Maps, in appointing a special committee in 1938 on nomenclature, was recognizing a real need for a clear understanding of language employed in technical publications, in official reports, and even in the oral discussions at meetings of the Board. The committee examined such common terms as *course*, and found that in one member bureau, *course* meant direction only, while in another it was used to indicate direction and distance, and has still other meaning in other fields of engineering. *Island* was another confusing term. The committee found that *island* is an especially important term in diplomatic language.

When the Board was abolished by Executive Order in 1942, the work of defining surveying and mapping terms was continued under the direction of the Chief of the Division of Geodesy, United States Coast and Geodetic Survey, under instructions that studies be limited to terms in which the Division of Geodesy had some interest. The results of these studies appeared in 1949, in a special publication.[1]

Among the terms for which the committee had completed definitions are two of unusual importance, not only to engineers but to many others. These are the terms *precision* and *accuracy*. While the work of the committee was before the Board for discussion, the members of the Board were questioned as to their understanding of these two terms. The variety of answers furnished a very dramatic demonstration of the need for the committee's work.

The definitions prepared by the committee are as follows:

PRECISION—Degree of refinement in the performance of an operation or in the statement of a result.

That was the whole definition, but the committee added the following supplementary statement: "Precision relates to the quality of execution, and is distinguished from *accuracy* which relates to the quality of the result. The term *precision* not only applies to the fidelity with which the required operations are performed but by custom has been applied to the methods and instruments employed in obtaining results of a high order of *accuracy*. *Precision* is exemplified by the number of decimal places to which a computation is carried and a result stated. In a general way, the *accuracy* of a result should determine the *precision* of its expression. *Precision* is of no significance unless accuracy is also obtained.

[1] Definitions of Terms Used in Geodetic and Other Surveys (U. S. Coast and Geodetic Survey Special Publication No. 242). *Government Printing Office*, Washington, D. C. Price, 45 cents.

Reprinted through the courtesy of *The Military Engineer*, November–December 1950.

For the term *accuracy*, the committee prepared the following definition and supplementary statement:

ACCURACY—Degree of conformity with a standard.

"*Accuracy* relates to the quality of the result, and is distinguished from *precision* which relates to the quality of the operation by which the result is obtained.

"The standard of reference may be (1) an exact value, such as the sum of the three angles of a plane triangle is 180°; (2) a value of a conventional unit as defined by a physical representation thereof, such as the international meter, defined by the International Prototype Meter (bar) at the National Bureau of Standards; (3) a survey or map value determined by refined methods and deemed sufficiently near the ideal or true value to be held constant for the control of dependent operations, such as adjusted elevations of permanent bench marks or the graticule of a map projection. The *accuracy* attained by field surveys is the product of the instructions to be followed in the execution of the work and the *precision* with which those instructions are followed."

All engineers are, or should be, familiar with *precision* and *accuracy*. They do not mean the same thing, but are complementary terms. If one appears in a technical report or paper, the other may be around, if not expressed, then as a silent partner.

SPIRIT OF THE WORD

A word may be possessed of several spirits: that given it by the one who writes it, and those found in it by the ones who read it. Though often identical, they are not necessarily so. This is well demonstrated by the misunderstandings rife in current discussions of national and international affairs. How diametrically opposite are the interpretations given by experts to some of the important provisions of statutes and agreements.

In *Special Publication No. 242* there are 13 kinds of *latitude* defined, and, with one or two exceptions, every one of them is different. There are definitions of 12 kinds of *parallax*, and of more than 20 kinds of *error*, but only 1 of *blunder*.

A word in particular use should have one and only one meaning, susceptible of exact definition. Rev. James M. Gillis wrote "A definition that varies with the context is not a definition, but a convenient epithet to be used by a speaker, at his own discretion, to designate whatever he intends to designate." And many centuries ago Marcus Aurelius Antoninus gave us the maxim: "Be not careless in deeds, nor confused in words, nor rambling in thought." In engineering language: Let *precision* be your guide, *accuracy* your goal!

Mississippi River Flood Control and Navigation Maps

The Mississippi River Commission has announced the availability of the 1952 edition of flood control and navigation maps covering the river from Cairo, Ill., to the Gulf of Mexico. This is the 20th edition of this map folio and it has been prepared from the latest information. Some data as late as August 1952 are included.

The map folio comprises 62 detail maps, scale 1:62,500, and certain supplemental sheets giving plan details, mileage, and other valuable information. The map sheets are 13¼ by 20 inches in size. The detail maps are primarily for general navigation of the river but contain much additional topographic and hydrographic information, such as flood control construction, township, range and section lines and numbers, 5-foot contours, and early meander lines from about 1820.

The map folio may be purchased for $2.00 from the Mississippi River Commission, P. O. Box 80, Vicksburg, Miss. Remittance should be made payable to the Treasurer of the United States. Separate maps are not purchasable.

New Reconnaissance Maps of Alaska

By GERALD FITZGERALD

CHIEF TOPOGRAPHIC ENGINEER, U. S. GEOLOGICAL SURVEY

THE COMPLETION within the next several months of reconnaissance topographic maps at a scale of 1:250,000, covering the entire Territory of Alaska, will mark an important milestone in American cartographic history. There are several reasons why the compilation and publication of these maps, covering an area of more than half a million square miles, is worthy of special note by members of ACSM.

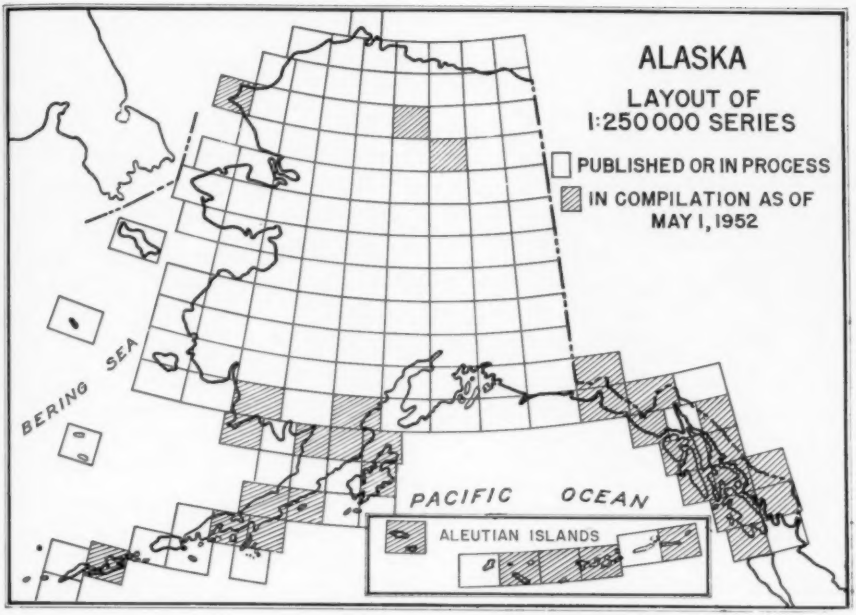
To the engineer interested in the development of surveying and mapping, a study of the techniques used during the past 50 years to produce reconnaissance maps of Alaska presents a graphic story of progress from early exploratory surveys to modern field and office methods. To the cartographer, the assembly, evaluation, and adjustment of thousands of items of source data, such as route surveys, maps at various scales, control information, and aerial and ground photographs, presented a colossal compilation task. This called for considerable judgment and critical analysis throughout the job and the use of all the "tricks of the trade" available. The most important result of this effort for the map user, of course, will be the availability of generalized topographic map information needed by the military to plan for the defense of Alaska, and by other agencies of the Federal and Territorial Governments as an aid to resource inventories and development.

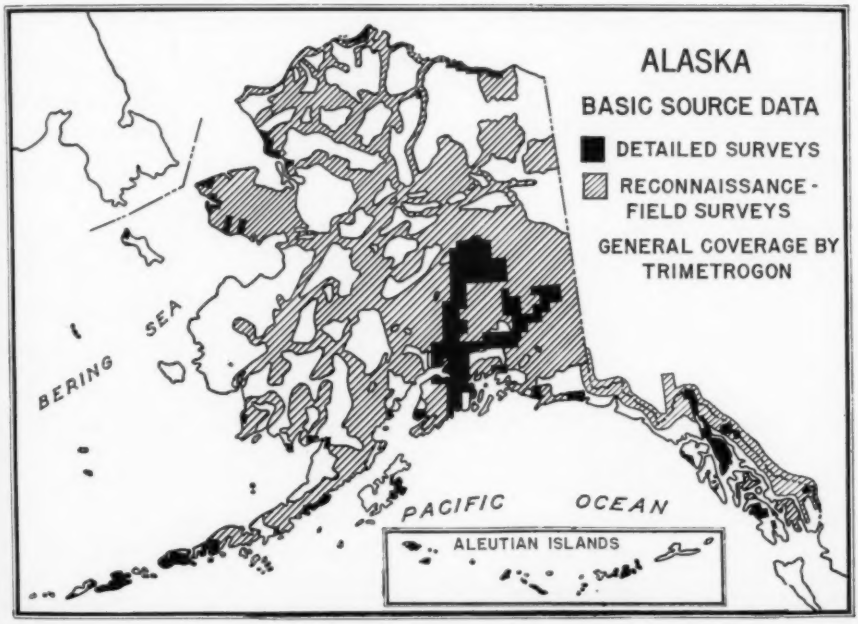
From 1898 to 1940 most of the topographic mapping in Alaska was done by the Geological Survey for publication at a scale of 1:250,000 with a contour interval of 200 feet. The early field surveys were made principally by the planetable method and for the most part were adjusted to horizontal and vertical control established by the topographer in the field. For reasons of economy, geologic and topographic parties were usually combined and assigned to areas of potential interest to the development of the mining industry. This often resulted in topographic maps being made of irregular and widely separated areas, and printed on sheets ranging in size from 10 by 12 inches to 36 by 42 inches. Thus, at the beginning of World War II the map coverage of Alaska consisted of a patchwork of surveys and route traverses which, in aggregate, covered nearly half of the Territory.

The early field surveys for reconnaissance topographic maps were made at a scale of 1:180,000. The topographer measured his base line, established geographic positions by astronomic observations, and expanded instrumental and graphic triangulation over the area to be mapped. Elevations were often determined by barometer or by long traverses from previously mapped areas. During the winter months when work was carried on in subzero weather, micrometer traverses were sometimes used in the valleys when it was impossible to occupy higher stations for control. Eventually, when many of these isolated areas were joined together by new surveys, numerous adjustments of the terrain detail were necessary.

Under ordinary conditions Alaska field work can be carried on for about 100 days, and this short season, combined with difficulties of transportation by dog team, canoe, and pack train required the topographic engineer to use every means at his disposal in order to expedite his work. It was for this reason that phototopographic methods were used as early as 1905 to supplement the planetable for reconnaissance mapping.

Presented at the Twelfth Annual Meeting, American Congress on Surveying and Mapping, Washington, D. C., June 11–13, 1952.


ALASKA
LAYOUT OF
1:250000 SERIES
PUBLISHED OR IN PROCESS
IN COMPILATION AS OF
MAY 1, 1952
BERING SEA
PACIFIC OCEAN
ALEUTIAN ISLANDS


ALASKA
BASIC SOURCE DATA
DETAILED SURVEYS
RECONNAISSANCE -
FIELD SURVEYS
GENERAL COVERAGE BY
TRIMETROGON
BERING SEA
PACIFIC OCEAN
ALEUTIAN ISLANDS

Spurred on by the success of the panoramic camera which he perfected, J. W. Bagley conceived the idea of developing a multi-lens aerial camera as an aid to reconnaissance mapping. This camera and its accompanying transforming printer were designed with the assistance of his co-workers in the Alaskan Branch of the Geological Survey and were built and used by the Army in World War I. However, the T-2 camera was not employed in Alaska until 1926 and 1929, when 20,000 square miles were photographed in southeastern Alaska by the Navy. Planimetric maps were compiled from the multi-lens photographs and used as a base for the 1:250,000-scale reconnaissance maps, prepared by field planetable methods.

The Army Air Force photographed a wide strip of territory between Seward and Fairbanks during the prewar years and this coverage was used to revise the existing reconnaissance maps—particularly the drainage detail in lowland areas.

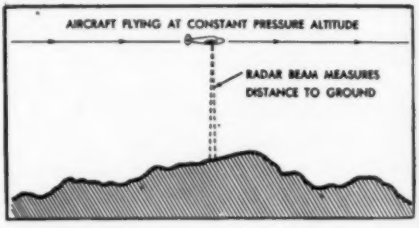
During 1939 and 1940 the multi-lens camera was used by the Geological Survey to obtain reconnaissance mapping coverage of parts of the Tanana Valley and the lowland area between Nenana and McGrath.

Before World War II the Wilson photoalidade was developed and used to map from terrestrial and oblique aerial photographs. It played a prominent part in the development of the "trimetrogon method," which was designed primarily to utilize aerial photography in the preparation of exploratory and reconnaissance maps, and to provide more reliable source data for aeronautical charts.

From the beginning of hostilities in World War II all mapping in Alaska for the Quarter Million Series was stopped and work was concentrated in the Washington Office on the compilation of aeronautical charts from trimetrogon photographs. By the end of the war much of Alaska had been covered with this photography which was compiled and adjusted to existing control and new astronomic positions established by the Air Force.

Although reconnaissance field surveys for small-scale maps had been suspended during the war, there has been greatly increased activity in many parts of Alaska since that time in preparing maps at a scale of 1 mile to 1 inch from vertical aerial photography obtained by the Air Force and the Navy. This new work furnished additional information for the production or revision of the Quarter Million Series and in its execution several methods were developed to expedite field work for topographic mapping. Perhaps the most important from the standpoint of actual accomplishment is the use of the helicopter by the Survey since 1948, and this, in many respects, has revolutionized mapping in Alaska.

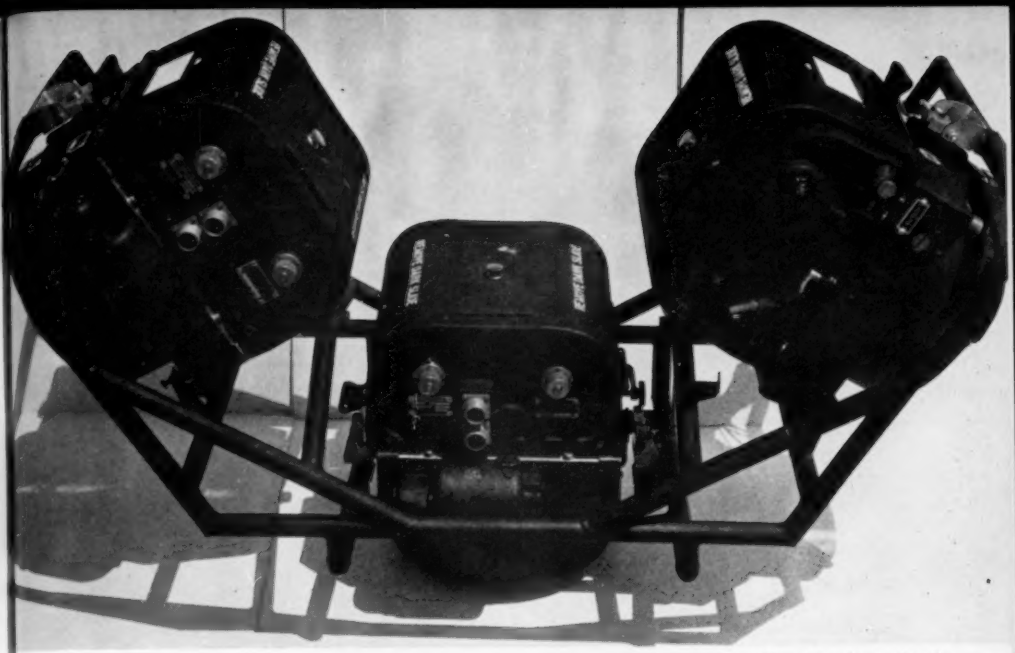
Airborne shoran has also been used to provide horizontal control in parts of interior Alaska, and experimental work has been conducted with airborne altimetry for vertical control of the same areas, in an effort to reduce the cost of field work and to provide better maps.



PRINCIPLE OF AIRBORNE ALTIMETRY

In 1947, the Geological Survey began the design of a uniform series of topographic maps at a scale of 1:250,000 to replace the 40 sheets of various sizes which had been published before the war, and which, although covering a total area of nearly 250,000 square miles, were for the most part unjoined and unadjusted to the standard North American datum.

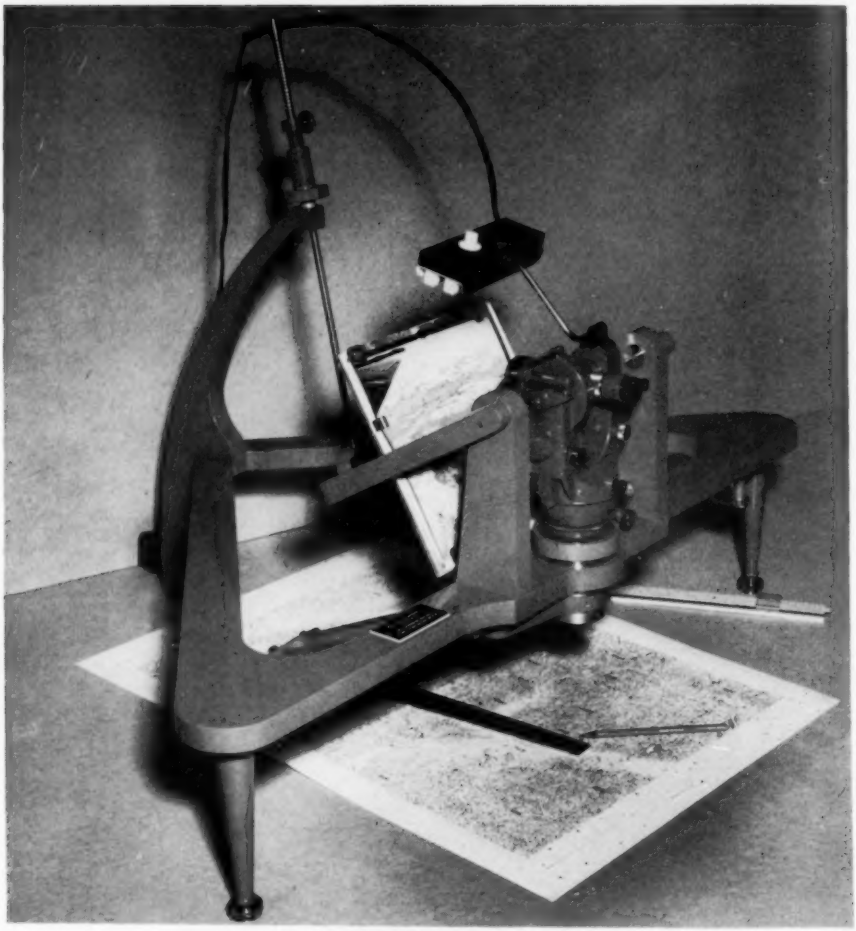
The new sheet layout contained 153 quadrangles, each covering 1° of latitude and from 2° to 3° of longitude. The Universal Transverse Mercator projection was



Courtesy U. S. Air Force

THE TRIMETROGEN CAMERA ASSEMBLY

REMOTE STATION OCCUPIED BY HELICOPTER-BORNE CREW



THE WILSON PHOTOALIDADE

employed, instead of the conventional polyconic projection, in order to facilitate military use and to effect junctures with the sheets of the Canadian national topographic map series of the same scale. The general specifications called for 200-foot contours where adequate source material was available, and provisional 1,000-foot contours where such could be developed by reconnaissance phototopographic methods for the poorly mapped or unmapped areas.

In 1948, the preparation and publication of the new Alaskan Quarter Million Series was given a top priority when we were asked by the Office of the Chief of Engineers to produce a provisional issue of the entire series covering all of Alaska by July 1, 1953.

In order to meet this deadline, it was necessary to postpone further new field surveys of the unmapped or weak sectors of the small-scale maps and it was decided to assemble and use all existing

source material in the provisional editions. Revisions would be taken up as new material became available but the objective of the immediate program required top speed in compilation and publication. The compilation from trimetrogen coverage of Alaska, prepared for the Air Force during the war and adjusted to the best control available, has been used in most areas to provide not only additional cartographic information but to ensure a reasonably uniform horizontal position adjustment.

As source material for each individual sheet was adjusted and compiled, a search was made for readily available new material from the files of the Coast and Geodetic Survey, the Army Map Service, the Aeronautical Chart Service, the Bureau of Land Management, and other agencies. On some sheets additional topographic information was compiled from trimetrogen photographs with the aid of the photoalidade. Before publication a composite proof was referred to interested government agencies and others for corrections, criticisms, and suggestions.

Relief-shaded editions of nearly all sheets of the Quarter Million Scale Series will be published in order to accent many of the striking topographic features of Alaska and to make the maps more interesting and readable to the user. Three drawings are prepared by airbrush and other special techniques developed during the war. Where good reconnaissance topographic base maps are not available, the trimetrogon photography serves as a guide for relief shading.

The entire compilation program is carried out at our Rocky Mountain Region in Denver and, to date, 110 sheets have been published; 18 sheets are in reproduction; and compilation of the remaining 25 sheets will be finished during the next few months, completing the 153 sheets of this series.

These new reconnaissance maps, when published, will provide the Department of Defense with full coverage of Alaska for military planning. The published sheets thus far available are in great demand for civil aviation and are popular with the "bush pilots" and the many others who use maps extensively. They will also provide a means for the preliminary planning of transportation routes, and will serve as a base for generalized geologic studies and mineral inventory maps until more detailed maps are required. As work progresses on the preparation of the mile-to-the-inch series, the Quarter Million Series will serve as an aid to planning photographic coverage and control operations for the larger-scale series.

Topographic maps at a scale of 1:250,000 have been published by the Geological Survey for more than 70 years and for many of the undeveloped areas in the West the early Quarter Million Scale quadrangles were *the* topographic maps until they were replaced by larger-scale sheets. The improvement of the planetable mapping method closely paralleled the early production of reconnaissance maps of western United States and Alaska. More recently, as we have seen, photogrammetry, shoran, altimetry, and the helicopter have been used ingeniously and effectively in improving and expediting the preparation of the new Alaska Quarter Million Scale Series.

Because of the large amount of undeveloped and rugged terrain in Alaska, and the high cost of the work, mile-to-the-inch and larger-scale mapping will probably be confined to restricted areas for many years. This means that the 1:250,000 scale topographic quadrangles should be maintained and improved for both civil and military use. The Geological Survey plans, as rapidly as funds and other priority schedules will permit, to make full use of all the modern field and office mapping techniques in bringing each one of the 153 maps of the Alaska Quarter Million Series up to the standard specifications of the scale. In the meantime, however, we are proud to present this provisional series as a major contribution to the National Mapping Program.

Training Surveyors and Mappers for the U. S. Army Engineers

By COL. F. O. DIERCKS

CHIEF, DEPARTMENT OF TOPOGRAPHY, THE ENGINEER SCHOOL, FORT BELVOIR, VA.

THE U. S. Army Corps of Engineers, the branch of the Armed Forces charged with the preparation of military maps for ground combat and their distribution to all arms and services of the Department of Defense, is vitally concerned with maintaining a steady flow of trained enlisted replacements to Engineer field mapping organizations. The principal organizations are: the Base Engineer Topographic Battalion; the Army Engineer Topographic Battalion; and the Corps Engineer Topographic Company. The first of these is assigned to a Theater Headquarters, the second to a Field Army, and the third to an Army Corps. Each has three primary elements: surveying, photomapping, and map reproduction. In the battalions these elements are of company size, and in the Corps Topographic Company they are of platoon size.

The mission of Engineer topographic organizations is to meet the requirements for strategic and tactical maps of the commands to which they are assigned, and to provide survey control data to the artillery for both conventional artillery weapons and guided missiles.

These topographic organizations cannot carry out their mapping and surveying missions with regular combat engineer soldiers, no matter how brave or talented, unless these soldiers are especially trained in the required surveying and mapping skills. These skills have been divided by the Army into the following groups: surveying units—topographic surveyor and topographic computer; photomapping units—map compiler, multiplex map compiler, and cartographic draftsman; and map reproduction units—process photographer, platemaker, and offset pressman. All are trained at the Department of Topography of The Engineer School at Fort Belvoir. We also teach three other courses in the Department: general drafting, construction drafting, and construction surveying, but graduates from these courses do not go to topographic organizations.

The courses vary from 8 weeks for the reproduction courses to 16 weeks for topographic computing, with the others between 10 and 12 weeks each. It is obvious that, in such short times, the previously inexperienced men we normally receive as students cannot be made competent and skilled in these technical fields. The best we can hope for, and I think we achieve it in most cases, is to turn out a semi-skilled graduate who has a good basic knowledge of the subject and can complete his learning by further on-the-job training in his unit.

Most students enter the Engineer School from a Replacement Training Center after completing 8 to 16 weeks basic training as a soldier, although some are sent to the School by their unit later in their military careers. Prerequisites for the Department of Topography courses are fairly high. We have an I. Q. requirement varying from average for map reproduction to considerably above average for photomapping and surveying courses. High-school graduation, or its equivalent, is desirable for photomapping and surveying skills, with additional credit for a course in trigonometry necessary in surveying and topographic computing. Normal color vision and stereovision are required for the map compiling, multiplex, and cartographic drafting courses.

Although established primarily for Army purposes, the surveying and mapping courses at the Engineer School, in line with service unification, are equally available to the Navy, Marines, and Air Force, who do not operate corresponding schools. In fact,

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about half the student body in the Department of Topography normally comes from the other services, primarily from the Air Force. Female components of the Armed Forces may also send students, and a few women are normally found in all the classes except, to date, surveying.

The student capacity of the Department, including the courses in general drafting, construction drafting, and construction surveying, is approximately 975, and in the surveying and mapping courses alone, there are 675 students. The annual output of surveying and mapping graduates is, therefore, about 3,000. To teach this number of students the Department of Topography has an authorized staff and faculty of 240, consisting of 30 officers and 210 enlisted instructors—a ratio between students being taught and faculty of about 4 to 1. Most of the faculty have had previous experience in Engineer topographic organizations in the field, mostly overseas, and therefore know their subject both theoretically and practically. Prior to teaching, all instructors must take a special course in Instructional Methods; that is, the techniques of presentation and evaluation of instruction.

I would like to describe briefly the scope of the surveying and mapping courses, hitting only the high spots, and none of the details, of each.

The topographic surveying course of 10 weeks covers triangulation, traverse, and leveling for third-order basic control and fourth-order picture-point control for stereophotogrammetric mapping. It also includes field astronomy, planetable mapping, and astronomic position finding with the pendulum astrolabe equipment. It provides graduates suitable for assignment to survey platoons of Engineer topographic organizations engaged in establishing ground control for stereophotogrammetric mapping.

The construction surveying course, also of 10 weeks, is slanted toward the requirements of construction work rather than map control and stresses the surveying needed for road and airfield layout and building construction. It includes the basic principles of triangulation, traverse, and leveling, plus setting of slope stakes, earthwork calculations, horizontal and vertical curves, and the use of the planetable and alidade. Students in this course use the 20-second transit and standard engineer dumpy level

ABBOT HALL

Headquarters of the U. S. Army Engineer School, Fort Belvoir, Va.

A TOPOGRAPHIC COMPUTING CLASS IN FIELD ASTRONOMY

instead of the Wild T-2 theodolite and military (precise tilting) level which are standard equipment in military topographic surveying. Recording and field computations are taught in both courses. Graduates of the construction surveying course are assignable to Engineer Construction Battalions, Aviation Battalions, Navy Seabees, and other units needing construction surveyors.

In the topographic computing course of 16 weeks, students are trained in the office computations required for the adjustment of triangulation, traverse, and level nets by the various methods, including least squares, as well as in the standard computations of astronomic and geodetic positions, map projections, and grids. This course stresses the use of standard forms, natural functions, and 10-bank automatic desk calculators, although logarithmic solutions are taught also. Graduates of this course are normally assigned to survey platoons of Engineer field topographic units engaged in photogrammetric mapping.

In the map compiling course of 10 weeks, students are trained to plot projections and control, run a radial-line plot with slotted templates and by other methods, contour with the stereocomparagraph, compile planimetric and topographic map detail with the sketchmaster and the reflecting projector, lay controlled and uncontrolled mosaics, and utilize trimetrogon photography.

The multiplex map compiling course, for which the map compiling course or equivalent knowledge is a prerequisite, devotes 10 weeks to training in multiplex operation, including plotting control, projector orientation, compilation of stereo-pairs, and multiplex control extension and adjustment. You can understand that, in this course particularly, we do not produce finished opera-

tors in the time allotted, but we do obtain surprisingly good results in 10 weeks of concentrated effort. Both map compiling and multiplex map compiling graduates are assigned to photomapping platoons of Engineer topographic units.

The cartographic drafting course of 11 weeks stresses the training of a fine hand for color-separation drafting of map compilations for reproduction. It also includes training in Army Map Service style sheets, stick-up, LeRoy and freehand lettering of maps, editing, and a limited amount of time on photomapping principles and map compilation from photos with transparent overlays and sketchmaster. Its graduates also are assigned to photomapping platoons of Engineer topographic units.

The three map reproduction courses of 8 weeks each train enlisted men as process photographers (copy cameramen), platemakers (including graining and layout), or offset-press operators. The camera used is the 24- by 30-inch Corps of Engineers precision copy camera and the press is the Corps of Engineers standard 22- by 29-inch Webendorfer Big Chief, the same equipment which is truck-mounted in the mobile map reproduction train of field Engineer topographic units to which graduates of these courses are sent.

No Engineer officer topographic courses are being taught at The Engineer School at this time, but such courses exist and can be placed in operation as the requirement arises for surveying, photomapping, or map reproduction officers. Each course is of 8 weeks duration and is designed to orient an Engineer officer for duty as a platoon commander in a topographic unit in one of the three fields of military topographic engineering.

The training given in the courses described is of the trade-school rather than the college type, that is, the stress is placed on practical application with the hands rather than on theory. We do teach, by lecture and conference, a limited amount of basic theory properly spaced throughout each course, enough in general to satisfy even the more brilliant of our students. The largest part of the instruction, however, is by doing, by practical exercises under supervision: in the field, at the drafting table, the multiplex booth, photo laboratory, or press room. The heaviest weights in our grading system are also placed on the practical exercises, with a lesser weight assigned to the examinations given periodically and at the ends of the courses to check the efficacy of instruction.

Fortunately, there are available at the School for use in training, ample quantities of standard mapping equipment and supplies—the same type the student will use later in his unit. We seldom have to place more than two students at a press or in a multiplex booth, or to overcrowd a survey party. This is essential if each student is to receive the maximum results from his accelerated course. The ratio of instructors to students, 1 to 4, is of course high for lecture classes, but is essential for supervising practical exercises in large drafting rooms, instructing each small survey party, and answering students' questions in multiplex booths or while performing inverse-position computations.

Another provision, standard in most service schools, is a written master lesson plan covering in detail the material to be presented in each hour of instruction in each course. Such a lesson plan lists the text references for the material to be covered, the training aids or equipment to be used, and then spells out exactly what the instructor is to say during the lecture or do during the practical exercise. This does not mean that the instructors read their lectures; on the contrary, they do not, but they do study them before going to the class as a refresher to insure logical and complete coverage. The lesson plan remains on the instructor's lectern, to assist him if necessary, throughout the period of instruction. This prevents faltering or gaps; it insures sound instruction because master lesson plans must be approved by course supervisors before being presented. Perhaps the most important feature is that the master lesson plan provides continuity of instruction when instructors are transferred to other assignments. Of course, lesson plans are not static, neither is the general pro-

gram of instruction itself. Each instructor assigned to the Engineer School is expected to improve the lessons he teaches by adding to them from his field experience or by further study. Course supervisors, officers, and senior non-commissioned officers frequently rewrite the entire program of instruction for certain courses—always for the better, we believe, for as the years pass there is more and more experience to build on.

Texts used are both civilian and military. The many excellent civilian texts on surveying and mapping, such as those by Breed and Hosmer; Davis, Foot, and Rayner; and the Manual of Photogrammetry are in constant use. Much of our instruction is based on U. S. Coast and Geodetic Survey Special Publications and U. S. Geological Survey Bulletins, but mostly we use the Engineer Field and Technical Manuals on surveying and mapping written at The Engineer School or the Army Map Service. These cover most of the fields of surveying, photomapping, drafting, and map reproduction; they may be purchased from the Superintendent of Documents, the Government Printing Office. I personally know that many civilian colleges use them.

CELESTIAL NAVIGATION SPHERE DEVICE

This useful training aid consists of a terrestrial globe surrounded by a 24-inch celestial sphere and surmounted by an altitude-azimuth dome, all in transparent plastic. The sun can be manually moved along the ecliptic.

And finally, in order to impart the most knowledge in the extremely limited times available to us for each student, we make the maximum use of visual training aids. Those of you who are engaged in education, and in most other pursuits, are aware that more can be taught by employing several senses than one sense alone. Tasting and smelling have little application in surveying and mapping, but hearing, which we all normally over-employ, touching, and seeing certainly do. Touch, along with sight and some hearing, is our big teaching factor in practical exercises. In lectures on basic theory, where hearing alone is usually employed, and to distraction, we make every effort to add visual aids to illustrate the explanations, and hence to ensure the understanding of the student. These aids include training films, film strips or slides, window-shade or other type charts, physical models, and, of course, where possible, the very equipment being discussed, or even better, cut-away models of it.

In conclusion, since results are the measure of achievement, I believe I may say that the surveying and mapping courses of The Engineer School have proved themselves well worth while. In spite of receiving many students who do not meet the prerequisites, of a more rapid turnover of instructor personnel than we would like due to overseas requirements, of acceleration and shortening of courses due to changing world conditions, we have managed to graduate successfully almost 90 percent of our entering students and to furnish nearly 3,000 qualified technicians per year to all the Armed Forces. These specially trained personnel are now at work maintaining the efficiency of Army, Navy, Air Force, and Marine topographic and construction units in order to speed more quickly the day of destruction of our country's enemies and the completion of the world's mapping and building programs.

The Quebec Procès-Verbal of Boundary

By D. I. O'GALLAGHER, Q.L.S.
PRESIDENT, CORPORATION OF QUEBEC LAND SURVEYORS

IN choosing a title for this paper I have in mind the fact that land surveying owes much of its distinctive character to the intimate relationship of the surveyor's practice to the legal aspects of real property. This fact has always given the surveyor a special standing in the community and it is upon this sound traditional foundation that we should continue to build our professional structure of the future.

At the 1949 meeting of the American Congress on Surveying and Mapping, Charles C. Lindsay of Montreal, Vice President of the Corporation of Quebec Land Surveyors, read his very comprehensive paper entitled "The Legal Status of the Surveyor in Canada,"[1] in which he gave a fairly complete outline of our Quebec procedures directed towards the legal establishment of a boundary line, permanently and irrevocably, by the signature of the coterminous parties in a land surveyor's *Procès-Verbal.*

I am dwelling again on the subject of the *Procès-Verbal,* because in our practice it forms the most important link uniting the practical and judicial expressions of our laws of real property. In this text I use the French terms *Procès-Verbal,* meaning report or minutes; *borne,* meaning boundary post or stone; and *bornage,* meaning setting of boundary.

Quebec civil law is French law, based on the Code Napoléon, hence our procedures follow long-established and fairly rigid forms, but without limiting our technical methods of measuring. Therefore, in undertaking a boundary case, a surveyor must possess, in addition to sound technical skill, a thorough familiarity with particular legal procedures and a knowledge of the application of laws. He must also have a better than ordinary understanding of human nature because he is dealing with people—aroused people, aware of their rights and critical of the surveyor's acts. His work, opinions, and writings are also subject to the scrutiny of legal men and of the courts.

A boundary case is the test of a young surveyor's ability. To begin with, he is definitely "on his own." He is acting as a public officer and this capacity is heightened if he has been named a "Surveyor Expert" by a court.

Whether the case is a conventional (amicable) bornage or a judicial one, the surveyor must be prepared to weigh conflicting evidence, face possible hostility, read deeds, and study plans. He must meet the parties in the case, their representatives, witnesses, and lawyers, and often a gallery of curious onlookers at a free and sometimes very dramatic show. No doubt this situation is met by surveyors the world over and I mention it here only to stress the need for the special training I refer to further on.

Assuming that all formalities in a bornage have been complied with, the actual survey and plan finished, and the boundary marks set and recorded, our surveyor must then complete his operations by drawing up his Procès-Verbal. The tension does not cease until he has secured the signatures of both parties on this document.

Mr. Lindsay's paper is quite detailed as to the contents of the Procès-Verbal but what I wish to emphasize is its value as a legal instrument, fully recognized in our legal system as a document of great weight and dignity.

I cite the following judgments to show this:

(1) "Once the Procès-Verbal has been signed by the parties it constitutes a definitive title between them as to the contents and limits assigned to each. If the bornes be moved or disappear each party may ask for their replacement

Presented at the Twelfth Annual Meeting, American Congress on Surveying and Mapping, Washington, D. C., June 11–13, 1952.

[1] *See* SURVEYING AND MAPPING, Vol. X, p. 191.

without it being necessary to proceed to a new bornage." (*Spratt & The E. B. Eddy Co.*, 4 K.B. 534). (From art. 154, Marler's "Law of Real Property—Quebec.")

(2) "Until the report has been signed by both parties, each may repudiate what has been done to fix the boundary" (*Morel* v. *Dame Bilodeau*, 50 S.C. 437, 51 S.C. 406). "When the report has been signed and thus accepted by both parties, the boundary fixed is final and cannot be reopened unless there is some grave reason showing its insufficiency or irregularity" (*Nadeau* v. *St. Jacques*, 13 R.L. 321; *Thorton* and *Trudel*, 14 R.L. 286).

(3) "The Procès-Verbal ceases to have effect however if 30 years elapse from the disappearance of the bornes, or if it is established that there has been a possession of 30 years contrary to the limits indicated in the Procès-Verbal" (*Aubry & Rau*, 11, No. 199, text, and notes 30 and 31). The Procès-Verbal, made by the expert but not accepted by the parties, is not final, but only the judgment homologating it and ordering the planting of the boundary marks is final.

(4) "A Procès-Verbal of boundary, signed by the parties and accepted by them, is a complete answer to the demand for bornage and constitutes a legal delimitation of their properties, as long as it is not set aside by the court, even if this Procèe-Verbal states that only one borne has been planted in the front of the estates of the parties and limits itself to the statement that a line-ditch serves as the division line in depth" (C.S., 1884; *Nadeau* v. *St. Jacques*, 13 R.L. 321, MATHIEU, J.).

(5) "Where the Plaintiff fails to maintain his pretentions respecting the line of division, he should be held for the costs of the suit; but the costs of the expert Surveyor's operations, report and plan affixing the bounds and placing the boundary marks, should be divided equally between the parties" (C.S., *Cosgrove* v. *Magurn*, 10 L.N. 163, WURTLE, J.).

(6) "That the boundary of two adjoining lands can be proved only by a signed Procès-Verbal by the owners of such lands. The building of a fence in accordance with a verbal agreement is not a bornage."

(7) "Bornage is a judicial act which is perfect only by the intervention of a tribunal or by a public functionary called a sworn Surveyor of the Province of Quebec."

(8) Conventional bornage or any other act of bornage has not the finality of a court action, and does not prevent one from having recourse to the courts.

(9) "Fences established and recognized since 30 years do not constitute a bornage, but they furnish proof of a public and precise possession."

The above are a few examples from a large volume of our jurisprudence in which the surveyor's Procès-Verbal is involved. One of our Quebec lawyers states that he reviewed 300 actions in boundary while preparing a thesis on boundary laws. Although this bespeaks a well-ordered judicial system, it also points to the dire need for boundary control and for proper survey, amicable bornage, and technical description before passing deeds of purchase. I have noticed that land surveyors generally, and our professional associations or corporations, have been rather slow to call the attention of the public to these services so as to induce a greater number of prospective property purchasers to consult the land surveyor before their property transactions get underway.

Bornages are best decided by what is contained in the title deeds (intrinsic evidence); so it follows that we must constantly remind prospective landowners, their lawyers, notaries, and trust companies, to have proper surveys made and descriptions written before passing the title.

The relationship between the bornage and legal surveys and other activities concerning property normally comes through new subdivisions of land, town and community planning, reports, certificates of survey, valuations, et cetera. The combination of training and experience, sound judgment, and sense of values brought to play in the orderly assembly of physical and legal facts fits the surveyor for a leading role in the public life of his community; on planning boards, municipal councils, and in State, Provincial or Federal Governments.

The training in basic subjects needed for modern surveying has been dealt with very competently in two papers recently given in Quebec. The first, by the worthy President of this Congress, Prof. George H. Harding, was delivered before the Canadian Institute of Surveying and Photogrammetry in February 1952. The second, by Prof. Zephirin Rousseau, Director of Studies at

Laval University School of Surveying and Forestry, was read at the annual meeting of the Corporation of Quebec Land Surveyors in April 1952. Both these gentlemen insist on a separate curriculum for surveying and mapping, branching away from civil and forestry engineering.

Zephirin Rousseau used the expression "A complete divorce from the other professions is needed." In his Laval courses he is adding more hours of geodesy and photogrammetry and a greater number of lectures on laws and procedures; dropping subjects related to forestry and substituting elements of municipal engineering. I think that a number of social science subjects should be added because the surveyor's practice is so closely related to the welfare of people, bearing in mind that the whole aim of modern community planning is to establish and maintain a sound social order. This indicates a better foundation for our future surveyors; however, I think we should pause here and face the question our prospective students are already asking us: What are the opportunities for employment, adequate remuneration, and promotion?

No doubt the giant strides in surveying and mapping techniques made at Washington and Ottawa and the increased application of photogrammetry in the appraisal and development of natural resources will require an increasing number of our type of trained men; yet, in my own Province the positions offered are comparatively few, promotion to administrative rank is slow, and salaries are below the range of comparable positions in other fields. My conviction is that our diversified services must be better understood by the public before we can hope for due appreciation of our graduates by the leaders in government circles.

I look to our professional organizations for greater efforts in this field of public relations. The action needed would be along the following general lines:

(1) Take steps to estimate the possibilities of employment for surveyors; to predict the approximate number of graduates per year that can be assured of profitable continuous employment.

(2) Establish closer contacts with the local groups—lawyers, notaries, and trust companies—in order to understand one another's viewpoints and to agree on standard practices in resurveys and correct technical descriptions of property to implement deeds which affect or change ownership.

(3) Stimulate our public relations by sustained, dignified publicity directed towards the administrators of real property and towards prospective homeowners, in order to bring more frequent consultations to our surveyors in private practice.

We must bear in mind that our professional organizations are granted exclusive privileges by the legislators because of a need for professional ability in legal surveying. Consequently, whatever our organizations do to consolidate this advantageous position is bound to be reflected in more widespread recognition of our services from the public level up to the more restricted government circles.

Although these last observations appear to meander from my title subject, I can readily close my circuit by returning to the long-established starting point of legal surveying. My Procès-Verbal can then be concluded with the declaration that our profession has always been the practical application of science in the expression of property laws. We take our bearings from God's stars to establish permanent lines on His earth to serve our fellowmen in their peaceful exercise of rights in private property.

❦ ❦ ❦

SAFEGUARDING MONUMENT

The sandstone marker denoting the center of England has been moved 200 yards to safeguard it against possible destruction from a skidding motor truck.—*The Evening Star,* Washington, D. C., May 15, 1952.

The Use of the Subtense Bar

By MICHAEL V. SMIRNOFF, M.S., C.E.

LECTURER, DEPARTMENT OF ENGINEERING, UNIVERSITY OF CALIFORNIA, LOS ANGELES

IN SURVEYING, as in other engineering fields, new instruments and new techniques are coming into use. A considerable interest is being shown at the present time in the use of the subtense bar in connection with measuring horizontal distances. This article intends to show the degree of accuracy that can be expected in such measurements.

A subtense bar is a device consisting of a bar which can be supported horizontally by a tripod while it is set over a point. The bar is usually made of invar and carries two targets, one at each end. The distance between the targets is accurately made to conform to a definite length. In Wild's model this length is 2 meters. The procedure in measuring a distance between two points consists in setting up a transit over one point and the subtense bar over the other, and then measuring the angle subtended by the length of the subtense bar. After this has been done, the horizontal distance is easily obtained by computations, or from a table which is usually furnished with the subtense bar.

Figure 1 shows the plan view of such a measurement. Let D be the distance measured between the transit point T and the subtense bar AB set over a point C. Assuming that e is the error in measuring angle α, it can be seen from the figure that d will be the error in measuring horizontal distance D, if MN is drawn parallel and equal to AB.

Since the lengths AB and d would ordinarily be small as compared to distance D, the following relations will be accurate enough for the purpose of the present discussion:

$$MK = (D - d)\,\frac{e}{2} = d \tan \frac{\alpha}{2},$$

where

$$\tan \frac{\alpha}{2} = \frac{AB}{2D};$$

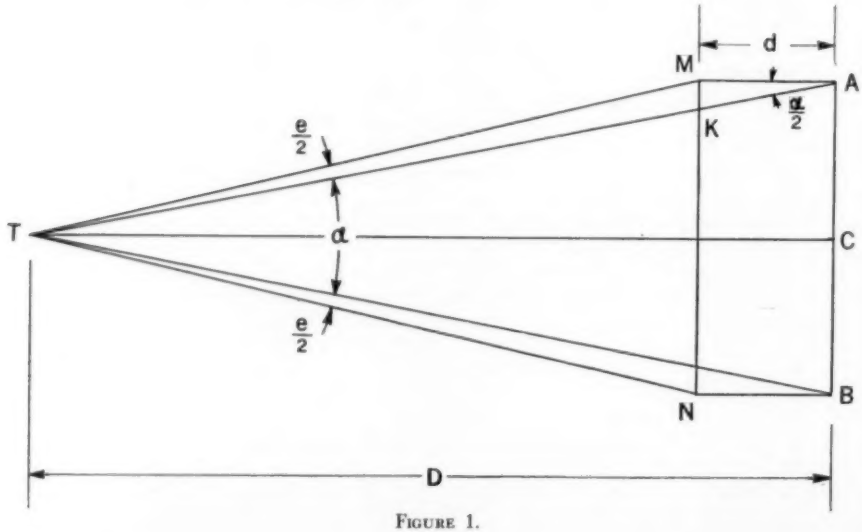

FIGURE 1.

thus

$$d = \frac{(D-d)\,eD}{AB}$$

or

$$d = \frac{D^2 e}{AB} \text{ (approx.)} \qquad (1)$$

The proportional accuracy in measuring distance D will be then

$$\frac{d}{D} = \frac{De}{AB} \qquad (2)$$

where e is in radius.

Taking $AB = 6.5617$ feet (2 meters), and expressing angle e in seconds and distance D in feet, the following expression results:

$$\frac{d}{D} = \frac{De}{1{,}353{,}000}. \qquad (3)$$

It is immediately apparent from (3) that if $e = 1$ second, the accuracy in measuring 100 feet is $\frac{1}{13{,}530}$, and that in order to maintain a constant accuracy of measurements the error e must vary inversely as the measured distance D. Let it be required, for instance, to measure distances with an accuracy of $\frac{1}{10{,}000}$. Substituting this for $\frac{d}{D}$ in (3) and solving for e, one can easily obtain the limiting value of e in measuring any distance D.

Table 1 shows this relation for $\frac{d}{D} = \frac{1}{10{,}000}$. For any other accuracy of measurement the values of e in table 1 will change proportionally.

TABLE 1

D in ft.	e in sec.
100	1.35
200	0.68
300	0.45
400	0.34
500	0.27
600	0.23

Table 1 shows that a subtense bar, of the type discussed in this article, must be used in conjunction with a theodolite that will measure the angles with a certain degree of accuracy. A theodolite with which one can read angles directly to 1 second and estimate tenths of a second, such as the Wild T2 for instance, can give very good results if proper judgment is used in measurements.

It can be expected that the probable error in measuring one small angle with a 1-second instrument will be about ±0.7 second under favorable atmospheric conditions. Each instrumentman using this method should endeavor to determine his probable error in measuring angles. The probable error can be decreased by using the repeating method in measuring the angle. An angle can be measured either an odd or even number of times, since both sights are at the same elevation and there is no need to balance the direct and reverse readings as the error of collimation does not enter into the measurements.

Table 2 shows what may be the expected probable errors in measuring an angle a varying number of times with a 1-second theodolite under normal conditions. It will be seen that the probable error after 5 repetitions decreases so slowly that it would be almost foolish to measure the angle more than 8 or 10 times. Yet, by comparison with table 1, it can be seen that that is just about what one would have to do in order to measure a distance of, say, 300 feet with an accuracy of 1 in 10,000, i.e., within 0.03 foot.

TABLE 2

No. of Measures	Probable Error in sec.
1	±0.7
2	±0.5
3	±0.4
4	±0.35
5	±0.31
6	±0.29
7	±0.26
8	±0.25
9	±0.23
10	±0.22

It will be observed that in obtaining the conclusion in the preceding paragraph the probable error of ± 0.22 second for 10 repetitions was doubled when it was used for e in table 1. The reason for this is as follows: When a probable error is applied to the measured value, one obtains two limiting values of a measured quantity, and according to the definition of a probable error, the chances are even that the true value will lie within or outside those limits. Therefore, it is reasonable to assume that one will actually get about twice as good accuracy from table 1 when a probable error is used instead of e in that table. In order to avoid such an exaggeration the probable error of table 2 may be doubled before it is used in table 1.

In a closed traverse with sight distances of about 300 feet, one can sometimes expect a better accuracy in closure than 1 in 10,000 even with fewer repetitions, for probable errors are compensating errors, and sometimes they may compensate to an amazing degree.

The above discussion has not taken into consideration any inaccuracy in the length of the subtense bar itself. The errors due to such an inaccuracy are of a cumulative nature, although they should not be large if a bar of a reliable manufacturer is used. It can be found from figure 1 that an error in bar length of 0.1 mm. will produce a 0.005-foot discrepancy in measuring 100 feet.

In conclusion, it may be said that the subtense bar in the hands of a discriminating user has a definite possibility in measurements. Where a good accuracy is required readings should be limited to the shorter distances, if possible. If longer distances must be measured, a proper number of repetitions should be used in turning the angles.

In the Jan.–Mar. 1952 issue of SURVEYING AND MAPPING, E. J. Coon of the U. S. Geological Survey describes the use of the subtense bar in measuring short bases. They used 150-foot sight distances with three direct and three reverse measurements of each angle. It was found that 90 percent of their runs were within 1 in 10,000 of the mean of all runs. A 1-second theodolite was used on these runs.

American Society of Photogrammetry To Hold Nineteenth Annual Meeting

THE Nineteenth Annual Meeting of the American Society of Photogrammetry will be held on January 14, 15, and 16, 1953, at the Shoreham Hotel in Washington, D. C.

A pre-program tour of the Engineer Research and Development Laboratories, Fort Belvoir, Va., will be held for registered members and students Tuesday afternoon, January 13.

The technical sessions will open in the afternoon with a welcoming address by President George D. Whitmore of the U. S. Geological Survey, followed by an address by Maj. Gen. Herbert B. Loper, Chief, Armed Forces' Special Weapons Project. A highlight will be a paper on "New Developments in Canada." Other papers are scheduled on "New Developments in Plotting Instruments" and the new "ER-55 Projector."

On Thursday morning, January 15, a three-dimension, sound-and-color movie on photogrammetry in private surveying will be presented. The session will include a paper on "Weather Forecasts for Aerial Photography." A panel on "Arctic Mapping" will be featured in the afternoon. One Canadian and one American are slated to discuss each of the following topics: "Early Exploration," "Aerial Photography," " Horizontal and Vertical Control," and "Mapping." The fifth topic, "Charting of the Sea Lanes and Harbors," will be discussed by U. S. Coast and Geodetic Survey speakers.

All day Friday, January 16, will be given over to "Photo Interpretation," with a panel scheduled for the morning session. The afternoon session will be featured by reports of the several working groups of the Society's Photo Interpretation Committee, which has been conducting investigations for the past 2 years.

Real Property Descriptions Based on the California Coordinate System

By C. A. WOOLDRIDGE, JR.
JUNIOR CIVIL ENGINEER, ALAMEDA, CALIF.

THE California Coordinate System was legally established by the Legislature of the State of California by adopting Chapter 1307 of the Statutes of 1947. One typographical error appeared, which was corrected by Chapter 134 of the Statutes of 1949. These laws legalize the use of a Lambert conformal projection established by the United States Coast and Geodetic Survey and recommended by many engineers. New Jersey was the first State to adopt such a system, in 1935.

The law permits, but does not require, the use of the California Coordinate System. It does require that the positions of control monuments based on the California Coordinate System shall be determined by triangulation or traverse methods conforming to the standards for second-order work as established by the United States Coast and Geodetic Survey. It further states that previously recorded information, plats, or descriptions shall prevail in case of conflict with a new description based on the Coordinate System.

The city of Alameda is fortunate in having taken advantage of the opportunity to have USC&GS traverse monuments located throughout the city at intervals of about every four blocks.[1] A city policy was established shortly thereafter that any property descriptions written by the city should be based on the California Coordinate System. However, lack of sufficient information and understanding of the Coordinate System and of surveying and of legal descriptions relating thereto occasioned a variety of styles and forms of legal description preparation by the engineering department of the city. Recognizing and seeking to remedy this situation, City Engineer B. H. Maynard instructed that adequate investigation and study be made and that a report be submitted proposing the best uniform style, form, and content to be followed in legal description preparation.

Numerous references and authorities have been consulted regarding the best way to write property descriptions based on the California Coordinate System. Some radically different ideas were obtained, but those incorporated herein are the most acceptable.

The description of a parcel of land for record purposes should have two aims. It should positively identify the land for title purposes. It should provide all necessary information for locating the land on the ground. These two aims are not identical. Most descriptions do not provide the information required for location, and a surprisingly large number do not even positively identify the land for title purposes, especially when based on the California Coordinated System, due to improper use of the system.

Property described in terms of the California Coordinate System can be located on the ground for all time to come, because the position occupied by a pair of coordinates cannot be "lost," as record corners or monuments can be. Only in the event of a major disaster would all the control monuments in one area be destroyed. Even then, control monuments can be replaced more accurately than is usually possible for "lost" survey corners as long as any of the USC&GS triangulation stations of the national network remain.

To identify the land for title purposes, any corner or line of record must be noted as being such, with reference to the deed. If the entire parcel being described is bounded by pre-existing property lines, each course must be qualified as being a certain line from a deed, with a reference to the deed.

[1] *See* "East Bay Triangulation Net," page 191, July-Dec. 1947 issue of SURVEYING AND MAPPING.

The preamble of a property description written for the city may be in either of the two following forms:

(1) "This area is platted as Parcel 1 on Drawing 3670, Case 51, City Engineer's Files, Alameda, California, which is hereby made a part of this instrument by reference."

(2) "As Exhibit A attached," in which case a legal-size photostatic reproduction of the drawing will be incorporated in the document.

The following statement should be incorporated in the body of the description to give a legal reference to the Coordinate System:

All bearings, distances, and coordinates are based on the grid of the California Coordinate System, Zone 3.

Concerning standard practice, the words "North," "South," "East," "West," and "feet" should be written out—not abbreviated. The symbols ° (degrees), ′ (minutes), and ″ (seconds) will be used. Most of our descriptions at the present time are for easements, so it may be well to note that the word "sewer" should not be used alone, but should be modified by "storm" or "sanitary," or both if required.

A line should never be designated as running "to Grand Street," but as running "to the centerline of Grand Street, 80 feet wide" followed by a legal reference to Grand Street (deed, subdivision map, etc.). Too many surveyors are prone merely to state, "as Grand Street now exists." This idea is fine if qualified by a recorded reference *and* "as said street now exists," but without a record reference, this will cause trouble for the title companies.

If there is more than one course between the control monument and the point of beginning, the description should "commence" at the monument, giving the coordinates with a reference to their origin. When starting at a USC&GS monument, the coordinates are "as published by the U. S. Coast and Geodetic Survey in Triangulation Description Book No. 943, a certified copy of which is filed in the City Clerk's Office, Alameda, California." When starting at a city monument, the coordinates are as shown on the record map, giving name, book, and page—never just the city drawing number. Then follow the required courses to the true point of beginning.

If there is only one course from the control monument to the point of beginning, the description should "begin" at the point of beginning, being a certain bearing and distance from the monument, and should give the coordinates and reference.

The ultimate aim of the Coordinate System is to have coordinates recorded for every property corner. All coordinate computations are based on information furnished by the USC&GS. Some authorities are of the opinion that this information should be recorded at the county recorder's office. Others make no reference to such an idea, the assumption being that the USC&GS is a public body and therefore authoritative enough. William C. Wattles, of Glendale, Calif., suggests filing a certified copy with the county surveyor or city engineer, which seems to be a fair compromise. We have a certified copy filed in the city clerk's office.

Coordinates of at least two points other than the control monument should be given in the description, usually record property corners and preferably at the extreme ends of the property involved. In the case of a description with numerous courses, it may be well to give the coordinates of several points. The accompanying drawing should show the coordinates of all record property corners and may show also the coordinates of all corners of the property being described. In any event, everything in the description *must* be shown on the drawing.

A SAMPLE DESCRIPTION

The following description may help to clarify some of the above statements. This is intended as a sample for form only. For particular wording and phrasing, reference should be made to Mr. Wattles' paper, "Description and Survey in Title," or other authoritative source.

Parcel No. 1: Alaska Packers Association to the City of Alameda. This area is platted as Parcel 1 on Drawing 3670, Case 51, City Engineer's files, Alameda, California, which is hereby made a part of this instrument by reference.

Being the easterly forty feet of Tracts 10 and 11 as shown on the hereinafter described Map of Alameda Marsh Land situate in the City of Alameda, County of Alameda, State of California, more particularly described to-wit:

COMMENCING at United States Coast and Geodetic Survey monument "Grand Clem," the coordinates of said point being $y = 469{,}459.83$ feet and $x = 1{,}493{,}742.85$ feet, as published by the United States Coast and Geodetic Survey in Triangulation Description Book No. 943, a copy of which is filed in the City Clerk's office, Alameda, California; said coordinates based on the grid of the California Coordinate System, Zone 3, as are all coordinates, bearings, and distances in this description;

THENCE along the extension of the line from United States Coast and Geodetic Survey monument "Clem Lafay" N. 60° 23′ 55″ W. 28.27 feet to the centerline of Grand Street, hereinafter described;

THENCE along the centerline of Grand Street N. 29° 49′ 25″ E. 6.08 feet to the north property line of Clement Avenue, 60.00 feet wide, as said street and avenue are shown on the Map of Town of Encinal and the Land Adjacent recorded in Book A at page 82 on July 25, 1854, in the Alameda County Surveyor's office, and as said street and avenue now exist;

THENCE continuing along the centerline of Grand Street N. 29° 49′ 25″ E. 39.05 feet to the southeast corner of Tract 11, as said tract is shown on the aforementioned map entitled "Map of Alameda Marsh Land as partitioned among the owners thereof in the suit numbered 8923 and entitled *Pacific Improvement Company, plaintiff, v. James A. Waymire, et al., defendants,* Superior Court of Alameda County, State of California" and recorded in book 25 of Maps at page 74, Alameda County Recorder's Office, said point having the coordinates $y = 469{,}492.94$ feet and $x = 1{,}493{,}740.71$ feet, said point being the TRUE POINT OF BEGINNING;

THENCE along the east line of Tracts 11 and 10, being also the extension of the centerline of Grand Street, N. 29° 49′ 25″ E. 357.63 feet to the northeast corner of Tract 10, the coordinates of said point being $y = 469{,}803.21$ feet and $x = 1{,}493{,}918.57$ feet;

THENCE along the north line of Tract 10, N. 60° 10′ 35″ W. 40.00 feet to a point;

THENCE parallel with and 40.00 feet distant from the east line of Tracts 10 and 11 S. 29° 49′ 25″ W. 366.31 feet to the south line of Tract 11;

THENCE along the south line of Tract 11 S. 72° 25′ 30″ E. 40.93 feet to the TRUE POINT OF BEGINNING.

In conclusion, it should be borne in mind that any coordinate system description for a parcel whose boundaries are of previous record should contain sufficient additional information to convey title, even if all coordinates, bearings, and distances were to be removed.

PROPERTY SURVEY ACCURACY STANDARDS OF THE CITY OF ALAMEDA

As mentioned before, the positions of control monuments must be determined by triangulation or traverse meeting the requirements for second-order work as a minimum. The long-established policy of the city of Alameda requires that all property surveys shall also conform to these requirements. Actually, we quite often obtain much greater accuracy. It has been recommended by the American Congress on Surveying and Mapping, and by many other interested organizations, that all property surveys, at least in urban and metropolitan areas, should conform to these standards.

The indications of second-order accuracy as established by the United States Coast and Geodetic Survey are:

(1) Closing error in position not to exceed 1:10,000.

(2) Probable error of main-scheme angles not to exceed 3 seconds.

(3) Closing angular error not to exceed 10 seconds times square root of number of angles.

We have been getting this accuracy by using a 20-second transit, reading both verniers and turning each angle 6 times with the telescope direct and 6 times with the telescope reversed, and then doing the same for the angle to close the horizon.

Chaining is done with a regular 100-foot steel tape which is checked regularly against a standardized invar tape. Chaining is done on chaining bucks (low rigid tripods with ball and socket swivel head). A tape thermometer is read for each tape length and the elevation of each tripod is read by level rod. Each distance is measured twice.

The reduction to sea level is not required in Alameda as our maximum elevation is only about 30 feet above mean sea level. Alameda is located in the center (in the north-south direction) of Zone 3, so the grid correction factor (1:14,000) should be considered for the most accurate work. How-

ever, even when ignoring it, we usually get a higher accuracy than that indicated but we can't state an accuracy higher than second order due to some of the USC&GS control being only second-order work.

By using the above methods and correcting for slope, temperature, tape length, horizon closure, and angular closure, we have turned out some very fine work. The "Official Resurvey" of about 225 acres of residential and industrial areas recently recorded is but one example of this.

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Map Exhibits at Centennial of Engineering

Among the exhibits displayed at the Conrad Hilton Hotel in Chicago during the Centennial of Engineering Convocation, September 3–13, 1952, were two map exhibits by agencies of the Federal Government—one by the Army Map Service and one by the U. S. Geological Survey. The Army Map Service exhibit displayed some of the techniques employed in producing maps of various scales and types required for the Armed Services of the United States. The USGS exhibit consisted of three panels, one of which displayed various maps produced during the past hundred years, another indicated the extent of current mapping operations, while the third showed examples of the thousands of modern government maps available for reference in many public libraries.

—ALFRED C. STIEFEL

Indiana Surveyors to Meet

Members of the ACSM are invited to attend a meeting of the land surveyors of Indiana which is scheduled to be held at Purdue University, Room 304, Union Bldg., on January 14 and 15, 1953. Arrangements for the meeting are under the direction of W. E. Camp of the Civil Engineering School of Purdue University, Lafayette, Ind.

Three Notes on Traverses

By B. GOUSSINSKY
SURVEY OF ISRAEL

1. *Standard Traverses or Adjusting Collinear Points*

PRELIMINARY

The object of surveying is the determination of the relative position of points in an area. The necessary operations consist of linear and angular measurements. The following are the three basic types of operations:

1. Triangulation—only angular observations are carried out.
2. Traverse—both angular and linear measurements are necessary.
3. Chain Survey—consists of linear measurements only.

The first two cases have been amply dealt with in surveying literature; not so the third. This is discussed here—first in theory, then in its application to practice.

STATEMENT OF THE PROBLEM

The main problem in chain survey is that of collinear points: Given the coordinates of the terminals of a straight line and the measured lengths of the sections forming the line, to find the coordinates of the end-points of these sections.

An adjustment is necessary due to the fact that the sum of the measured lengths, as a rule, differs from the total length of the line as computed from coordinates. As one can easily see, the case is that of a traverse simplified by the absence of angular observations and the necessity for angular adjustment. We shall call such traverses "standard traverses."

The more general problem of adjusting a network of chain survey lines is not considered here.

THE ADJUSTMENT

The problem is first considered in a one-dimensional space—coordinates along a straight line.

Three cases can be considered: when the errors of measurement are only systematic, or only accidental, or both systematic and accidental.

1. *Systematic errors.*—The solution in this case is obvious: *the discrepancy is distributed among the sections in direct proportion to their lengths* for the simple reason that errors, too, accumulate in direct proportion to lengths. Here the method of least squares is not applied, the errors not being accidental.

2. *Accidental errors.*—The condition equation is

$$[l] + E = 0 \tag{1}$$

deduced from

$$[L] - [C] = E, \tag{2}$$

and

$$[L] + [l] = C, \tag{3}$$

where L_i, l_i are the measured length of a section "i" and its correction, respectively, and C_i is the corresponding correct length of the section, so that $L_i + l_i = C_i$. E is the total misclosure. The brackets indicate a summation for all the sections.

Weights of measurements, denoted by P_1, P_2, ... , P_n, are in inverse proportion to the lengths of sections, since probable errors of measurements are supposed here to be increasing with the square roots of the lengths of sections. Thus

$$M_1 = M\sqrt{L_1},\ M_2 = M\sqrt{L_2}, \ldots\ldots,\quad M_n = M\sqrt{L_n}, \tag{4}$$

where M is the probable error of measurement per unit of length; and, therefore,

$$P_1 : P_2 : \ldots . P_n = 1/M_1^2 : 1/M_2^2 : \ldots . 1/M_n^2 = 1/L_1 : 1/L_2 : \ldots . 1/L_n. \tag{5}$$

The normal equation, obtained from (1) and (5), is

$$[L] \times k + E = 0 \tag{6}$$

wherefrom the correlative $k = -\dfrac{E}{[L]}$ and, finally, the corrections

$$l_1 = -\frac{E}{[L]} \times L_1,\ l_2 = -\frac{E}{[L]} \times L_2, \ldots\ldots,\quad l_n = -\frac{E}{[L]} \times L_n. \tag{7}$$

In other words, *the misclosure, in the case of accidental errors, is distributed, exactly as in the case of systematic errors, in direct proportion to lengths of sections.*

3. *Compound errors.* Here we have: $E = S \pm A$ where E, as before, is the total misclosure and S and A are its component parts, the results of accumulation of systematic and accidental errors, respectively. *As each of these components is distributed proportionately to lengths of sections, the same applies also to their algebraic sum.*

The formula $E = S \pm A$ holds good only when it is agreed to express the resultant of compound errors in the form:

$$E = [s \times L] \pm [a \sqrt{L}], \qquad (8)$$

where s and a are the probable systematic and the probable accidental errors per unit of length, respectively.

This procedure of simultaneous adjustment for systematic and accidental errors is similar to the adjustment of a spherical triangle with all angles observed with the same accuracy. The discrepancy—sum of angles minus 180°—is composed of the spherical excess and the sum of the accidental errors in angular measurements. These two values can be considered the systematic and the accidental component parts, respectively, of the total misclosure. By applying Egendre's rule to the spherical excess and that of least squares to the errors of observations, we arrive at the same procedure of distribution of each of these two values, viz., equally among the three angles. But the same procedure can also be applied to the total misclosure, arriving at the same results, and without the necessity of knowing the spherical excess and the observational misclosure of the triangle.

There is, therefore, a uniform rule of adjustment for all cases: *The misclosure is distributed in direct proportion to measured lengths, whatever the nature of the errors of measurement.*

THE PROBLEM IN TWO DIMENSIONS

Considering the projection of the measured line upon the axes of coordinates, one can easily see that the distribution of the total linear misclosure in proportion to lengths of sections is equivalent to independent distribution of the component misclosures along the axes in proportion to respective increments in coordinates. The adjustment can also be carried out, with the same results, by assigning corrections to the positions of the section endpoints on the line itself, or on their projections, in proportion to accumulated lengths or accumulated increments, respectively.

This means, in the case of standard traverses, that the three ways of ordinary adjustment, namely, the rule of incremental partition (the transit rule), the rule of parallel partition (the compass rule), and the rule of central partition (the rule of swing and scale), are identical.

For detailed discussion of the three rules of ordinary traverse adjustment the reader is referred to "Some Notes on Adjustment of Traverses," *Empire Survey Review*, No. 60, April 1946.

It may be added here that these three rules can be considered as corresponding roughly to the cases of systematic, accidental, and compound errors, respectively, in linear measurements.

THE IDEAL TRAVERSE

The standard traverse can be considered as some sort of an ideal traverse, since there is no question of angles in its adjustment, nor is any discussion required of the nature of errors in measurements. The closer a traverse approaches this form, i.e., the straighter a traverse is, the safer is its adjustment, and the surer we are that the solution is in agreement with reality.

Analytically this can be expressed as follows: the straighter a traverse is, the closer are the coefficients—sines and cosines of bearings—in each of the two independent condition equations in coordinates, and the easier it is to reduce each of the latter to the "standard form" of condition equation (1) by dividing all the coefficients by their common, or practically common, value.

GENERALIZATION

Assuming that errors in angular measurements are negligible as compared with those of linear measurements, let us con-

sider the three possible forms of traverses.

1. *Standard traverses.* The adjustment by proportional distribution of the discrepancy is equivalent to adjustment by change of scale, as if the only error were that of the standard used in the measurements. In other words, here all the possible errors are assimilated to those of the systematic kind.

2. *Ordinary framed traverses.* When a traverse is far from being straight, it is necessary to know the prevailing nature of errors that have affected the measurements in order to decide on the most suitable method to be adopted in adjustment.

3. *Closed circuit traverses.* At the other end of the scale we find the closed circuit traverses, in which the effect of linear systematic errors is nil, and in which the linear misclosure is compensated by considering all the errors as being of the accidental type.

COMPUTING COORDINATES FOR STANDARD TRAVERSES

In practice, the adjustment is carried out merely by dividing the total correct differences in coordinates into parts proportional to the measured lengths of the individual sections. This at once gives the corresponding correct increments. Thus, for the Y's we have

$$Y_1 = \frac{[Y]}{[L]} \times L_1 \ , \ Y_2 = \frac{[Y]}{[L]} \times L_2 \ , \ \ldots \ ,$$

$$Y_n = \frac{[Y]}{[L]} \times L_n \qquad (9)$$

where Y is the total correct difference in the eastings, etc. This can be easily ascertained from a figure, or from the following consideration

$$\frac{Y_1}{[Y]} = \frac{L_1 + l_1}{[C]} = \frac{C_1}{[C]} = \frac{L_1}{[L]},$$

since

$$\frac{L_1 + l_1}{[L]} = \frac{C_1}{[L]} = Q \qquad (10)$$

Q being the proportion factorial for all corresponding measured and corrected values.

Characteristic features of this way of computing coordinates are that the adjustment is carried out automatically without preliminary computations, and no tables are required.

EXTRAPOLATION

The described procedure of adjustment is applicable also to points situated outside of the main line, such as points on prolongation or on offsets and obliques. It being assumed that the same aggregate of errors has affected the main line as well as its subsidiaries, it is only logical to have these corrected too, and the above theory provides the means.

CHECK ON MEASUREMENTS

In this way the coordinates of all the intermediate points are found without knowing the correct length of the line or the misclosures. This facilitates computations but does not offer security against the possibility of a gross error in linear measurements, since the misclosure remains concealed, being automatically distributed among the increments. To obviate this, only a short additional computation is required. The coefficients

$$r = \frac{[Y]}{[L]}, \ t = \frac{[X]}{[L]} \qquad (11)$$

are squared and their sum is taken

$$r^2 + t^2 = \frac{[Y]^2 + [X]^2}{[L]^2} = Q^2 \qquad (12)$$

Q being, as before, the ratio of the correct and measured lengths of the line. This at once provides the accuracy of measurement. An example will explain this. Suppose that the tolerance is 1 : 1,000. Then, at the limit

$$Q = \frac{[C]}{[L]} = 1 \pm 0.001,$$

and

$$Q^2 = 1 \pm 0.002. \qquad (13)$$

If, thus, Q^2 is found to be between 1.002 and 0.998, the measurements are acceptable; otherwise the closure is excessive.

With the aid of Q the absolute value of the misclosure can easily be found if required.

GRAPHIC REPRESENTATION

It might be of interest to consider the geometrical interpretation of the above discussion.

All the Y's and X's are obtained by multiplying the measured values by the coefficients r and t, respectively, as if they were the sine and cosine of the bearing of the line. Actually, they are the sine and cosine of two different bearings, viz., r is the sine of an angle such that the projection of the total measured distance upon the axis of Y's is equal to $[Y]$. The same considerations apply to t and $[X]$.

The measured lengths of the individual sections are plotted along the two lines, r and t, both equal in length to $[L]$, and the projections of the end-points of these sections upon the axes of coordinates provide the required correct coordinates. From these the correct positions of the points on the main line can be found (fig. 1). The figure also shows the application of the principle to offsets.

Figure 2 shows the case of $r > 1$. This means that r here is the cosecant, not the sine, of the corresponding "false bearing," or that r is the sine of an angle such that the measured line is the projection of the total correct difference in the Y's. The graphic solution is carried out accordingly.

2. *The Transit Method of Traverse Adjustment—Arithmetics or Algebra?*

DESCRIPTION OF THE METHOD

As shown in "Some Notes on Adjustment of Traverses" (*Empire Survey Review*, No. 60, April 1946, p. 232), the transit method of traverse adjustment is applicable only when errors of systematic nature are assumed to have been prevailing in the measurement of traverse sides. The principle of the method is to have the misclosures along the axes distributed in

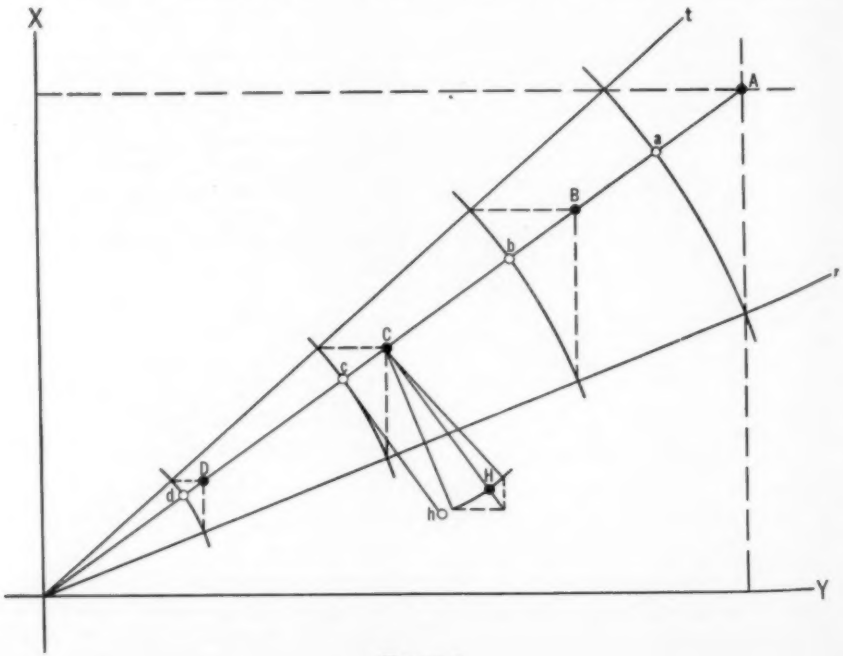


FIGURE 1.

proportion to the magnitudes of the corresponding increments.

If the traverse sides are affected by a certain systematic error, their projections on the axes of coordinates are affected, too, by a systematic error, which is the projection of the length error in the corresponding traverse leg. Due to the systematic error, all the traverse sides are altered in the same direction, so are also the increments, i.e., either all increased or all decreased in length. This must be kept in mind.

THE USUAL PROCEDURE

The way of adjustment, as described in textbooks, consists of distributing the misclosures along the axes in proportion to the *absolute* values of the increments, i.e., without taking their signs into consideration. The misclosure in the Y's, for example, is divided by the arithmetical sum of all the Y increments, and the ratio is multiplied by each increment, taken, again, as an arithmetic magnitude. This results, when applying the correction with its sign, in having certain increments increased, while other increments may be decreased in absolute value, a procedure which is obviously incorrect.

THE SYSTEMATIC ERROR

The systematic error is usually defined as being cumulative or noncompensating. This, however, is not always correct, and the difficulty comes from the confusion in considering the origin and the effect of errors. In length measurements, for instance, the distances obtained are affected systematically by an error in the length of the tape, either always too long or always too short. But when the effect of such an error on traverse closures is considered, the result is not always cumulative; it can be compensating, depending upon the relative bearings of the traverse legs. In a traverse which is far from being a straight line, the linear closure is smaller than in a traverse composed of the same traverse legs, but more nearly in a straight line. In the extreme case of closed circuit traverses, the effect is even nil.

THE CORRECT PROCEDURE

Considering the effect of systematic errors in length measurements upon the closures in the Y's and the X's in a framed traverse, one can easily see that here the effect of such errors may also be compensating, since they can be of opposite signs, the algebraic sign being a function of the bearing. In other words, the resulting errors in increments are cumulative algebraically, whereas the same errors in a straight line are cumulative arithmetically.

It follows, therefore, that the way to

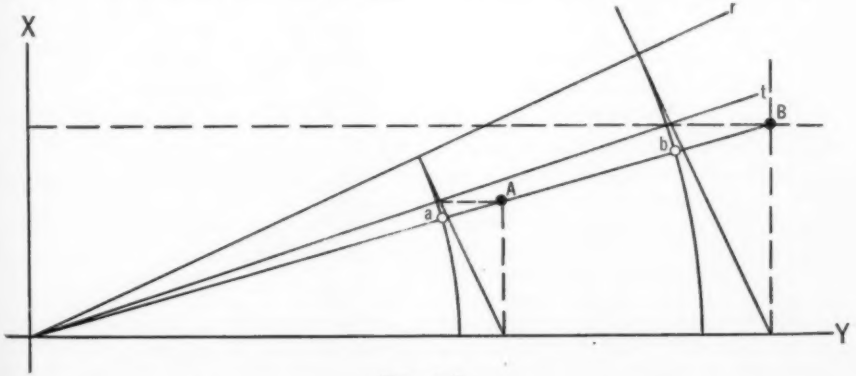


FIGURE 2.

obtain the true corrections for the individual increments is to divide the misclosures in the Y's and the X's by the corresponding total differences in coordinates (and this in absolute value does not always equal the sum of the absolute values of the increments) and then to multiply these values by the increments. In both operations the algebraic signs must be taken into consideration, thus the increments are either all increased or all decreased in absolute value.

The proportionality factor obtained by the correct method may, sometimes, be greater than that obtained arithmetically when increments happen to be of different signs—same numerator over a smaller denominator. This results in corrections that are greater in absolute value, but which more accurately represent the errors in the linear measurements.

ADDITIONAL CONSIDERATIONS

Let us take the case of an excessive systematic error in length measurements, all other errors being negligible. In this case the terminal point from the preliminary computations will fall practically on the line joining the terminals of the traverse line in their true positions (main axis of traverse), and the two component misclosures will be in the same proportion as the respective total differences in coordinates. In other words, the representative fractional errors are the same for both latitude and departure. If all measurements in a traverse network have been affected by the same excessive systematic error, the above ratio will be practically the same for all main traverse circuits of the network, and a general scale correction can then be applied to all of it.

This may provide a means for the detection and correction of a considerable systematic error in length measurements, should its presence be known or suspected.

Professor Förstner, in his note on rigorous adjustment of traverses ("Ausgleichung von Polygonzügen"—Zeitschrift für Vermessungswesen, Nos. 3 and 5, 1933), describes a method by which a traverse is adjusted simultaneously for all its accidental errors in angular and linear measurements, and, at the same time, for the systematic error in linear measurements. This error figures as one of the unknowns in the adjustment. This way of compensation, however, is too complicated to be used in ordinary work, for it requires the application of a special method of adjustment by condition equations with unknowns ("Bedingungsgleichungen mit Unbekannten"). From this point of view, both the detection and distribution of the systematic error in linear measurements is practically as good as, and with the transit method of adjustment it is certainly easier than, that of Professor Förstner.

3. *Traverse Circuit—Framed and Closed*

CHECKS

In a traverse circuit, all measurements, whether linear or angular, must have a check. This is obtained either by a superfluous number of observations which satisfy certain purely geometric condition equations, or by basing the circuit upon a framework of higher order points, position and orientation control. These latter closures, in addition to providing checks on the observations, also provide connections to the framework upon which the circuit is based.

THE PROBLEM

The following two points need clarifying:

1. How are complete position and orientation controls secured?
2. What is the exact definition of framed and closed circuits?

POSITION AND ORIENTATION CONTROL

Framed circuits do not always provide sufficient data for securing the correct connection with the framework. This is evident from the fact that besides errors

of observations there may also be errors of the objects, or the errors in identifying points of the framework. To have a check on this also a survey must be based upon at least three points.

With one fixed point a survey figure obtains only its configuration, without any indication as to the correctness of its orientation and position in relation to the system to which it belongs. With two fixed points an error of the object is not always detectable. Thus, a triangulation figure based on two points may be entirely in error with regard to position and orientation if one or both of the basic points have been misidentified.

FRAMED AND CLOSED CIRCUITS

Usually a traverse circuit is considered closed when the two terminal points are coincident, i.e., a traverse circuit is considered as closed, or framed, from the point of view of position control only, leaving out orientation. This is incorrect. A traverse can be framed or closed either in bearings, in coordinates, in both, or in neither of these, the two kinds of closures being independent of each other.

TYPES OF TRAVERSE CIRCUITS

All possible cases are illustrated by I through VII in figure 3.

I and II—Framed in both bearings and coordinates, with a complete check on orientation and position.

III—Closed in bearings, and without check on orientation so far. An error of misidentification will be discovered only when computing the coordinates, the traverse being framed in coordinates.

IV—Framed in bearings, closed in coordinates. Here a check is available on both orientation and position (except for the case when the misidentified location of point *B* lies on the circle through *A*, *B*, and *C*), there being three points upon which the figure is based.

V—Closed in both bearings and coordinates, and no check on position or orientation.

VI—Closed in bearings, no check on orientation which remains undefined. Also closed in coordinates, without any check on the position of the initial point.

VII—Open or "hanging" circuit. No closures whatever and no check on either position or orientation.

WHAT IS THE BEST FORM OF TRAVERSE?

Closed circuits, whether in bearings or coordinates, should, as a rule, be avoided. In the cases of IV through VI there is

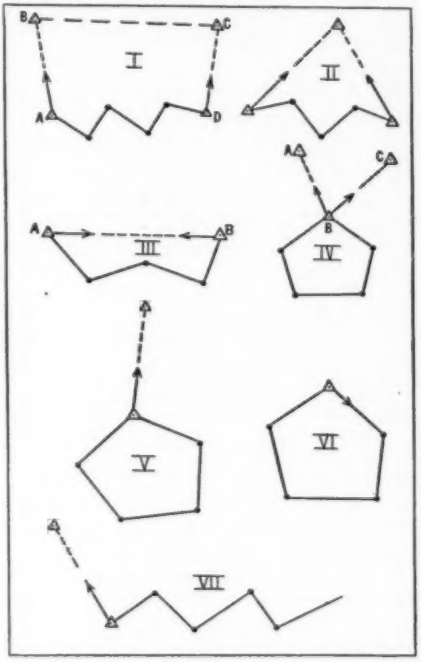


FIGURE 3.

no check on the scale (systematic error) of linear measurements—circuits being closed in coordinates.

A traverse line, to be secured against all possible errors, must be fully controlled in its two main parameters—scale and orientation. To ensure this, the safest procedure is to stick to cases I and II.

Operation Coldfoot

By COMMANDER KARL B. JEFFERS
U. S. COAST AND GEODETIC SURVEY

WHEN coal oil replaced whale oil in the lamps of the United States, interest in the Arctic part of Alaska decreased abruptly. Strange as it may seem, the search for oil reserves has taken us back to the Arctic. Coupled with this search is a renewed interest in global distances which has been accentuated by problems involving our national defense.

Economic development and military operations both require detailed surveys and maps. Our nautical charts of Arctic Alaska have been compiled from information furnished by explorers, and captains of whaling ships. Topographic maps based on trimetrogon compilations were produced during World War II. These charts and maps are based on very meager control. No basic surveys were attempted prior to 1945 with the exception of the Alaska-Canada boundary triangulation and the third-order work accomplished by Leffingwell at the beginning of this century.

ARCTIC ALASKA

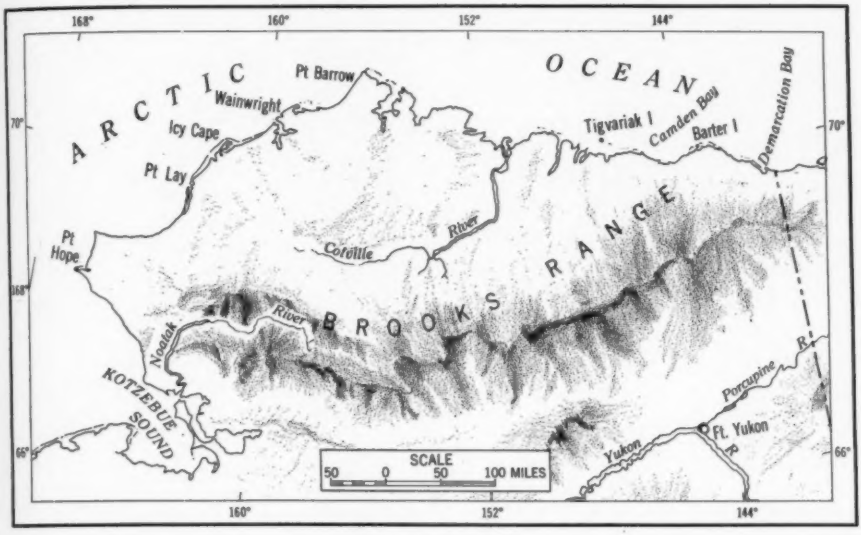
The Brooks Mountain Range extends in an eastward direction from Point Hope, just north of Bering Strait, to the Canadian boundary. To the north of this range, there is a barren plain which is only a few miles wide at the two extremities but which has a maximum width of approximately 200 miles south of Point Barrow. This project is concerned primarily with the coastal margin of this plain.

Many rivers from the mountain slopes cross the plain. These rivers begin to flow early in May, gradually moving northward until they reach the coast in June and are in full flood for a few weeks. The plain is covered with snow from October to June, although the depth of the snow seldom exceeds 6 inches on the level. During the short summer season the tundra becomes a green carpet dotted with millions of small and colorful flowers. There is a variety of animal life in the area; including brown bear, caribou, reindeer, wolf, wolverine, fox, and an occasional moose near the mountains. The plain is dotted with a myriad of lakes and ponds, some of considerable depth; a few of the lakes contain grayling in large numbers. Ducks and geese migrate to nest on the Arctic shores and many arrive before the ice has gone out. The inland areas are almost literally alive with mosquitoes during the brief summer season. Much of the coastal area is broken up into polygonal fields caused by frost cracks and ice wedges. From the air these fields have somewhat the same appearance as a dried mud flat.

There are two large Eskimo villages on the coast—Wainwright and Barrow. There are several small communities along the coast and a few Eskimos live along the rivers near the mountains. They are a cheerful and friendly people, quite religious, yet retaining many of the primitive superstitions of their race. The old sod hut, or igloo, has been replaced by frame dwellings, though most are still overcrowded. The Eskimo still hunts caribou, seal, walrus, whale, and birds, all in their season, but there are many who now earn their living by working for wages. They pay exorbitant prices for merchandise and are unmercifully gouged in late spring when flour and other staples are in short supply. The economy of the Eskimo has been drastically changed during the past few years; even our small activity has had its effect.

The Chukchi Sea is open to navigation about the middle of July with some scattered brash ice in evidence. Ships may not

Based on a paper given at the meeting of the Topography and Cartography Divisions of the American Congress on Surveying and Mapping, Washington, D. C., April 2, 1952.



ARCTIC ALASKA

safely go north of Icy Cape before the end of July, and must be constantly on the alert to avoid being trapped. Ice is nearly always visible off Point Barrow, and there is always danger that the pack may move in to the beach. A prolonged period of northeasterly winds moved the ice pack away from the beach at Point Lay early in July 1949. There was an open lead 2 to 3 miles wide along the coast. The wind shifted to the southwest reversing the flow of the current. As the ice pack approached the beach, it was traveling at a rate of approximately 2 miles per hour. The power developed by the ice hitting the beach, was amazing. Blocks of ice 6 feet thick and 10 feet square tumbled end over end or were pushed over other blocks until an ice ridge 20 to 30 feet high was formed. A ship caught in such circumstances would have been crushed and driven hard aground. Ice conditions are usually progressively worse eastward of Point Barrow. Although this area sometimes remaines ice free until late October, it is standard practice for all ships to get out before September 15.

The casual summer visitor is particularly impressed by the continuous daylight. The sight of the sun floating along the northern horizon is one experienced by very few Americans and one not easily forgotten.

SURVEY MISSION

The mission of the Coast and Geodetic Survey in the Arctic is to establish a permanent system of geodetic control around the perimeter of Alaska, to execute the photogrammetic and hydrographic surveys necessary to produce modern topographic maps and nautical charts of the coastal areas, and to collect related data on tides, currents, and terrestrial magnetism.

Field work in this area began in the vicinity of Point Barrow in 1945. Most of the overland transportation was by dog team, and the men lived in tents pitched at the site of the day's work. Caribou skins served as mattresses, and each man equipped himself as best he could to withstand the cold. Although a great deal was accomplished this first season, it was obvious that a different system would have to be developed for working in the areas further away from Point Barrow.

No field work was done in 1946. Arrangements were made to obtain motorized equipment and a few Jamesway huts. A large quantity of supplies was shipped to the Arctic with the 1946 resupply expedition. Four mess wanigans and six rigid pipe sleds were construction during the winter of 1947–48. Additional boats and motorized equipment were also obtained in sufficient quantities to outfit a second field party. During the early winter months of 1948 a cat train traveled from Point Barrow to Barter Island, a distance of about 400 miles, transporting boats, lumber, fuel, and additional tons of supplies and equipment. This was one of the longest cat-train operations ever carried out along the Arctic Coast.

TRANSPORTATION

Transportation was one of the first considerations in development of plans for surveys. It was obvious that supplies and equipment would have to be moved along the coast as the work progressed and new base camps were established. Two of these moves were made with the assistance of a contractor. The overland hauls have been greatly reduced through the use of LCM's (Landing Craft, Medium) to haul all but the heaviest equipment during the summer months. At the end of the hydrographic season, all boats are hauled out at the new base camp to avoid the necessity of hauling them overland by sled. Cat-train operations involved in a shift of bases are limited to the movement of wanigans, a few small buildings, and other heavy equipment. Short hauls are made to deposit supplies at selected temporary camps which serve as bases for hydrographic survey units.

Diesel caterpillar tractors ranging in size from D-6 to D-8 are used in this work. Each tractor is equipped with a towing winch and heavy steel cable. There is an art to driving a tractor in snow-covered areas. Occasional soft spots and drifts are encountered where traction is lost. The driver releases his cable and moves ahead to firm footing, and the winch is then engaged to pull the load up to the tractor. When the sleds are in proper position, and while they are still in motion, the tractor begins to move ahead. The winch is disengaged when the tow is in correct position. I spent a large part of one seemingly endless night in digging out a D-8 which was not equipped with a winch.

Transportation of personnel and light loads is accomplished by weasels or snow-jeeps. The weasel is an amphibious, tracked vehicle, developed during World War II. The model now in use is called a "Cargo Carrier, Amphibious, M-29-C." The bow tank has storage space for extra fuel, oil, and antifreeze. The weasel is fitted with a small winch mounted on the bow and geared to the crank shaft. Many of these winches have been disconnected as they are seldom used and must be disconnected whenever it becomes necessary to install a new fan belt. This is a time-consuming job and is no fun in subzero weather.

The weasel will carry four people and can tow small loads without undue strain on the tracks or transmission. It is equipped with a canvas shelter top with thin plastic windows. The plastic is very brittle and soon breaks. Most of these tops have been replaced by "hard tops" constructed of thin plywood or masonite which are much more durable and not very expensive. Such work is usually done during the slack period in June and July. These vehicles are used by triangulation and signal-building parties in winter and air-photo inspection parties in summer, and have many other uses around the camps.

Although they are amphibious vehicles, the use of weasels for crossing deep water is restricted to an absolute minimum. They have a freeboard of only a few inches, "swim" very slowly, and are difficult to maneuver in currents or moderate winds.

Snow-jeeps are half-track and ski vehicles which carry two passengers and can tow light loads. The skis on the front can be replaced by wheels for summer use. They are very satisfactory vehicles for use by reconnaissance units and signal-building parties. The type used by the Coast and Geodetic Survey is obsolete. We have restricted their use to the winter season and "dead line" them as soon as the snow is gone.

PROSPECTOR'S STEAM BOILER. FUEL DUMP IN BACKGROUND.

PORTABLE PREHEATER. NOTE COLD WEATHER CLOTHING—DEERSKIN MUKLUKS AND DOWN-FILLED PARKAS.

AL TRIANGULATION CAT TRAIN—SUPPLY SLED, MESS WANIGAN, AND BUNK WANIGAN.

WEASEL LANDING FROM AN LEM. DECK HOUSE ACCOMMODATES FOUR-MAN CREW.

WEASEL AND SKI-WHEEL TRAILER.

OVERHAULING D-6 TRACTOR.

The 35-foot rearming boat has been adopted for use as a hydrographic launch. The hull is constructed of marine plywood and is designed for high speed. The underwater part of the hull has been sheathed with thin copper plate to protect it from ice damage. A canvas-covered canopy was constructed on each launch and space is provided for emergency sleeping and messing. The boats are powered by Chrysler Crown engines with keel cooling systems. Water temperature is critical in the operation of these engines and must be maintained within a range of 125° to 140° F. for most efficient operation.

In addition to the LCM's mentioned previously, the party has two LCVP's (Landing Craft, Vehicle and Personnel) which are used for transporting supplies and equipment (fuel, lumber, weasels) to temporary camps. Deckhouses have been built on the LCM's with accommodations for four men. These boats were used to move a great deal of equipment from Point Lay, about 175 miles southwest of Point Barrow, to Pitt Point which is about 90 miles east of Point Barrow. This operation saved a difficult and relatively expensive cat-train haul.

The airplane is, of course, the answer to long-distance movement of personnel and supplies. There are regularly scheduled flights of DC-3's from Fairbanks to Point Barrow. These large planes have been used a few times to transport heavy loads to the base camps. Landing strips are cleared on lagoon or lake ice, but they are rather rough at best. The bush plane, which may vary in size from a Cub to a Norseman, is the prime mover in the Arctic. Personnel are transported between Point Barrow and the base camps in these small airplanes. Mail, commissary supplies, and emergency repair parts arrive by plane. Our camp at Point Lay served as a transfer point for the contractor on the airmail route from Kotzebue to Point Barrow. One never knows what plane may land next. The latchstring is always out in the Arctic to a variety of visitors—missionary, hunter, prospector, and tourist. The bush plane is equipped with skis in winter and pontoons in summer. There is a short period in spring and fall when neither skis nor pontoons can be used, and the plane must use standard wheel landing gear. Pilots never hesitate to fly when skis or floats can be used, but are very cautious when wheel gear is required, as there are relatively few places suitable for landing on wheels. This is no reflection on the courage of these pilots. In an emergency they will take almost any risk to save a life. As one pilot put it, "I don't know about you, but I am too young to die," and he turned around rather than fly through the fog.

HOUSEKEEPING

The second organizational problem might be called a housekeeping job. This includes housing, feeding, sanitation, water supply, warehousing, power supply, and maintenance.

The Jamesway hut was the answer to base-camp housing. This is a portable hut with wooden box floors, wooden bow framework, and blanket covering. The hut can be built to any desired length in multiples of 4 feet. It is well insulated and easily heated. The hut accommodates two persons for each 4 feet of length. Special bunk wanigans were built on skids to house triangulation parties working out of the base camp. They were built of rough lumber and insulated with sheets of celotex. Use of these wanigans increased the mobility of the field parties and greatly improved efficiency of operations.

Specially constructed mess wanigans on rigid pipe-sled bases are used for cooking and messing on the trail or in temporary camps. Seating space is provided for 12 men. A minimum of 1 month's supplies is stored in the wanigan before leaving the base camp. One of the Jamesway huts is used as a mess hall at the base camp. Resupply is by plane, weasel, or boat, as the occasion requires. Frozen meat is kept in an outside locker during the cold months. Small amounts of fresh vegetables and fruits are supplied periodically from Point Barrow. Dry stores and canned goods are drawn from the main-base supplies which are received 1 year in advance of contemplated use. Frozen foods are stored in ice cellars. These are constructed by driving

a shaft approximately 20 feet deep into the permafrost and enlarging the space at the bottom to a size sufficient to accommodate the stores which must be kept frozen. Meat stored in such cellars will remain frozen as long as it is kept there. All other supplies, except lumber and fuel, are stored in pyramidal tents.

Empty fuel-oil drums serve as garbage and refuse receptacles. All waste is hauled 1 mile or more away from the camp. One man is detailed to refuel and clean the stoves, service gasoline lanterns in winter as needed, haul ice or water to the various huts, move supplies as required, police the camp, and do various other camp duties.

A garage is required for repairing vehicles and overhauling various small motors and engines. This may be a wooden frame structure covered with canvas or an insulated building constructed on skids which can be moved from one camp to another. A combination office and radio shack is the center of activity in the base camp. TCS radios, fathometers, and other electronic equipment are serviced in this building. Frequent radio schedules are kept with Point Barrow headquarters and with any field parties operating out of the camp. During the hydrographic season, a radio watch on the standard channel is kept continuously whenever launches are at work in open ocean areas. So far there has been only one emergency situation which required the use of this service. A weasel had become waterlogged in the middle of a lagoon and had to be towed ashore. We were able to save the vehicle and some valuable records and equipment. Radio communications are occasionally disrupted by the so-called "radio blackouts." The blackout may continue for several days and is a matter of considerable concern since emergency action is completely dependent on radio communication.

SAFETY MEASURES

The third problem is concerned with safety of personnel. Before leaving Seattle, the personal outfit of each man is checked. He is furnished with a heavy parka, a pair of padded trousers, and flight boots. In the Arctic he is furnished with Eskimo mukluks and heavy leather mittens with woolen liners. Each man supplies his own personal gear and all clothing except that mentioned above. Colored glasses must be worn to prevent snow blindness. Every working party, in both summer and winter, carries down-filled sleeping bags and extra food and fuel when it leaves camp. A sort of "flight plan" is registered at the camp before the party departs, and an estimated time of return is agreed upon. Each boat and vehicle is coated with international orange paint for easy identification. This color is visible in all conditions of light and can be spotted at great distances. Radio schedules provide an additional safeguard. Each launch is required to tow a dory for use in case the launch must be abandoned. Each field unit has at least one Eskimo assigned to it to serve as a guide. A white man may become lost in a blizzard, but the Eskimo never loses his sense of direction and is able to find his way back to camp from any place, even though visibility may be reduced to a minimum.

FIELD WORK

There are three distinct seasons in the Arctic. The first is the period of the long freeze which ends in May or early in June when the rivers begin to flow, the ice becomes porous or rotten, and overland travel comes to a halt. Triangulation, signal building, base measurement, and some astronomic work are done during this period.

The second season is called the breakup season, and lasts from early June to mid-July. This period is used to complete triangulation computations, overhaul equipment, prepare for hydrographic work, take inventories, and prepare to receive the summer shipment of supplies. A tide gage is usually placed in operation by July 1. Everything stops on the Fourth of July so that the Eskimos may have their annual field day of dancing and athletic competition.

The third season begins with the departure of the sea ice in July and ends with the coming of freezing weather about the

middle of September. Although the ocean may remain ice-free for several weeks in September, the lagoons and sheltered anchorage areas freeze over very quickly. Daily water temperature observations are watched very closely, and the hydrographic operations are discontinued soon after the water temperature reaches 0° Centigrade. Slush ice begins to form at minus 1° C. and a further drop in temperature produces a layer of ice from 1 to 6 inches thick. The ice may be broken up by wave action but seldom clears away to permit small boat travel.

TRIANGULATION

The reconnaissance engineer is the first man in the field. The triangulation chain along the coast is comparatively narrow—usually about 5 miles wide. The land is generally level, and there are no conspicuous elevations which can be used for long line work. Time does not permit building many towers for the purpose, and visibility is usually limited by the glare on the snow and frequent snow fogs. A great amount of traveling is required to select points that will provide the maximum strength of figure. Considerable time must be spent at some stations in an effort to select a point which will be dry, as much of the upland is very wet in summer.

After a point has been selected and marked by a temporary beacon, the signal-building party establishes a permanently marked station which consists of a station mark, two reference marks, and a reference post. A standard signal pole with target is set up over the station mark.

The permafrost introduced a comparatively new problem in station marking. The prospector's portable steam boiler was adapted to our use and has proved a very excellent tool. Station and reference mark disks are brazed to 6-foot sections of 2- or 2½-inch pipe, in which several small holes have been drilled at top and bottom. Various kinds of pipe have been used, such as copper, wrought iron, and galvanized iron. The first pipe marks used were 3 to 4 feet long and have not been very stable.

The steam boiler operates at approximately 60 to 80 pounds pressure. It burns Diesel fuel oil, and forced draft is provided by a steam jet and atomizer after the pressure has been once raised. The nearest snow drift provides the necessary water. Steam is fed through a ⅜- or ½-inch steam hose to a steel pipe about 7 feet long with a "T" handle at one end, and a flat wedge-shaped jet at the other. A hole of sufficient size and depth to hold the pipe mark can be melted in the permafrost in 3 to 5 minutes. A little practice in use of the jet is required before the operator learns how to avoid having pressure build up under ground and a resulting eruption of muck and melted ice. I remember an Eskimo who returned to camp completely covered with black dirt and whose cheerful comment was, "Dirty work but clean pay." Certainly it was dirty.

Repeat measurements of horizontal distances between marks and spirit-level observations over the marks have been recorded at several selected stations during the past 4 years. Although the data are not sufficient to warrant positive conclusions, it appears that marks set in well-drained areas will hold their positions. In spite of the fact that sand beaches thaw to a depth of several feet, probably below the bottom of the pipe marks, there is little evidence of frost action on the marks. Marks set in marshy areas, on slopes, or near frost cracks, are subject to some vertical or horizontal movement. Marks set too close to the high-water line on low sand bars may be disturbed by storm-driven drift wood or creeping ice. A great many Eskimo markers—pieces of driftwood set on end in the sand or tundra—have remained in place for many years. Some such posts are known to have remained in place for more than 40 years. We have good reason to believe that our pipe marks will be permanent.

Nearly all triangulation observations are made with instruments set on standard tripods. The tripod legs are usually set on small wooden blocks to avoid creeping due to the melting caused by the pressure of the pointed tips. Theodolites equipped with

temperature adjusting devices can be used successfully in very cold weather; others are apt to bind or drag in temperatures lower than minus 10° Fahrenheit. Horizontal refraction is usually excessive on clear sunny days, and best results are obtained by observing during the late afternoon and evening hours. Efforts have been made to do triangulation after the snow has melted, but the lines of sight usually pass too close to the ground, resulting in excessive refraction, both horizontal and vertical.

Reconnaissance and signal building could be done much more efficiently in summer except for the problem of transportation. Also, there are so many other things to be done during this short season that personnel are not available.

Astronomic observations must be made in early spring, February to April, or in the fall, because of the continuous daylight in summer. Experience to date indicates that September and October are the best observing months, for temperatures are much too low for satisfactory work in February and March. Radio time signals are subject to protracted interruption in either period.

Base lines are measured at intervals as required for second-order triangulation. Methods do not differ from standard procedures except in the method of staking. The base stations are selected so that most of the taping is done across a frozen lake, lagoon, or small bay. The steam boiler is used to melt a hole in the ice of sufficient size to hold a 4- by 4-inch stake. Snow is packed around the stake which freezes solid in about 30 minutes. Although some base lines have been measured in very low temperatures, it is my opinion that it is best to delay this operation until May when tapes can be more easily handled.

HYDROGRAPHY

In areas where visual-fix control is to be used for hydrographic surveys, it is advisable to build and locate the signals required for this purpose while the triangulation observing program is in progress. If there is not sufficient time to build finished signals, temporary markers, such as flags or empty oil drums, should be set up and cut in by the observing parties. Permanent signals can be built later as time permits. The hydrographic season is relatively short and much time is lost because of bad weather. It is essential, therefore, to have all preparations for these surveys as nearly complete as possible before the ice goes out.

Hydrographic surveys are extended offshore to the 10-fathom curve if possible. This curve is 6 to 10 miles offshore in the Chukchi Sea but is only 3 to 4 miles offshore between Wainwright and Point Barrow. In areas where we have been unable to develop completely the 10-fathom curve, we have run dead-reckoning lines well offshore in order that a close approximation of the curve may be charted. The use of shoran to control hydrographic surveys has permitted their extension well beyond this curve and beyond the limits of visual-fix hydrography. Particular attention has been given to charting the channels between the islands and the mainland east of the mouth of the Colville River. These areas are sheltered from the ice fields and are open to navigation when ice breakers must be used in the offshore areas.

The continental shelf is 40 to 50 miles offshore along the north coast and extends westward from the Canadian boundary to Point Barrow where it turns sharply toward the northwest. Very little is known about the depth of the Arctic Ocean, as there have been only a few widely scattered soundings. A general depth of more than 2000 fathoms is indicated.

The tide along the Arctic coast has an average range of approximately 1 foot. Wind effect produces a maximum range of about 5 feet. Continuous strong northeasterly winds drive the water westward to the Siberian coast and produces minus tides along the Alaskan coast; southwesterly winds have the opposite effect. The wind is predominantly from the northeast; however, the strongest storm winds come from the southwest. The current flows through the Chukchi Sea in a northeasterly direction to Point Barrow with an average velocity of 0.5 knot, where it meets a west-flowing current of about the same strength and sets

up an eddy at their junction off the point. Protracted periods of northeasterly winds will reverse the current in the Chukchi Sea. Westerly winds will bring ice inshore west of Point Barrow.

While the majority of the personnel are engaged in hydrographic surveys, a small unit is occupied with duties ashore. Each triangulation station must be visited while the snow is gone so that complete descriptions of the stations may be written. Control points are spotted on aerial photographs, and the photographs are compared with ground detail for correct interpretation. This party also makes magnetic observations at selected stations.

It is expected that the Arctic project will be completed in 1953. The wholehearted logistic support by the Departments of the Army, Navy, and Air Force has contributed much to our success in the rapid completion of this survey. Those who have been assigned to duty there have thoroughly enjoyed the work in spite of their first fears of subzero weather, and this has now become a preferred assignment by many officers. The Arctic coast was our last frontier. The survey has presented a challenge to ingenuity, fortitude, and courage in many of its aspects.

* * *

The Beginning of Modern Road Maps in the United States

By HELMUTH BAY
RAND MCNALLY & COMPANY

DURING THE PERIOD preceding the acceptance of the automobile as a safe and practical means of transportation, highways were important only on a local scale. True, a number of roads extended for long distances into and across the country, but travel upon them was restricted primarily to comparatively short distances, even by stagecoaches. Travelers and tourists who desired to travel from one town to another 40 miles or more away used the railroad, electric line, and steamboat as primary transportation. On arrival at their destinations they hired a "rig" at the local livery stable and proceeded to execute their business or do their sightseeing by this means. In parts of the West the stagecoach was regarded as a rather important means of short-haul transportation as late as the 1920's.

Soon after the turn of the century, when the internal-combustion engine became a practical power plant for the wheeled vehicle, the transportation picture changed completely. Long journeys in automobiles were contemplated by the more adventuresome, and business and pleasure trips of several hundred miles were planned and successfully carried out.

Among the deterrents to automobile travel during this evolutionary period were unimproved highways and roads, lack of facilities at which gasoline, oil, and repairs could be obtained, and a lack of road maps whereby the traveler could find his way. In those days most roads were unmarked and unnumbered, and in large sections of the country there were no improved highways. Travelers were forced to inquire their way from farmers and others who lived along the route, for the few and widely scattered signboards carried puzzling hieroglyphics, difficult for any traveler to decipher. This presented a problem, of course, for the cartographer and mapmaker.

County maps were revised to include more accurate and detailed road information as the first step toward providing improved maps for motorists. However, even at their best, such local maps still lacked information as to the physical condition of the highways, so that selecting the best and most passable route was mostly guesswork on the part of a traveler unfamiliar with the locality. Visualize, if you can, using a road map, drawn on a scale much larger than our present road maps, with no roadmarkers or numbers to indicate the best through routes, without reference to road conditions, service stations, grades, or bridges; then, you have a picture of the confused traveler of that era. Furthermore, it was obviously more difficult to interpret and follow a map in the heavily populated areas than in areas where roads were few and far between.

It was during this period (about 1910), and in answer to a growing demand for maps and guides that would permit a traveler to take a trip by motorcar without losing his way a dozen times a day, that Rand McNally & Company of Chicago brought out their now-famous Photo-Auto Guides; among these was one that showed the best route from Chicago to New York and return. In addition to a detailed written description of the selected highways, it included a picture of every corner or point where the road changed direction (with identifiable features such as signs, houses, or trees indicated) and an arrow showing which way the traveler should turn at these points. These guides were quite popular for some years; however, only a few principal routes were covered, and the cost of printing and maintaining the guides was high. As a result, the demand for a more practical road map became even greater than before.

Various organizations, such as the Lin-

coln Highway Association, began to mark some roads about 1912; the objectives were to designate primary highways between large cities throughout the country. These organizations increased in number and, with the help of chambers of commerce and business men's clubs of various kinds, had marked about 30 primary U. S. highways by 1923. Among those early highways are the familiar Victory Highway, Yellowstone Trail, National Old Trails Road, Atlantic Highway, and Dixie Highway.

This activity was encouraged by Rand McNally & Company which realized that all roads and highways must be marked before useful maps could be produced. The Company undertook the task of marking additional roads and encouraged others to assist them in every way. About 1914 their field men were sent out to further this movement.

The automobile club or chamber of commerce of a central city was approached and asked to cooperate in the task of selecting the principal highways in that area and giving each one a name, symbol, or mark. Rand McNally in return agreed to make stencils of the symbols and to get permission from the local light or power companies to paint these marks on their telephone or power poles. A map of the region would then be made showing the marked roads, and it would be sold through the club, local newspaper, or other outlet at low cost. Advertising in the form of hotel lists, restaurants, etc., was included in the booklets which usually accompanied the maps.

The idea spread rapidly, and by the end of World War I road-marking activities had spanned the country. The Company's files of 30 to 40 years ago contain many notes and letters illustrating the Company's activities in the road-marking program. The problem of the mapmaker increased as more detailed and accurate information was acquired. Soon the Company was receiving cooperation from county, State, and Federal highway engineers in all parts of the country. In addition, its field men were kept almost constantly on the road checking mileages, road conditions, gasoline facilities, and tourist accommodations.

Toward the latter part of 1915, John Brink, who was responsible for the production of the early road maps of Rand McNally & Company, conceived the idea of numbering the roads. The idea grew, local cooperation was secured, and on March 1, 1917, Brink presented a map of the region around Peoria, Ill., which was the first map showing numbered highways. A short time later the roads in a part of southeastern Wisconsin were marked, and soon afterwards the State Legislature enacted a statute authorizing the system. Thus, in 1917, Wisconsin became the first State to adopt the numbered system of highway marking in use today. Minnesota followed suit, through a referendum in 1920.

The following is quoted from a recent letter from Wm. O. Hotchkiss, an official of the Wisconsin State Highway Department in 1917:

> I think it was early in 1915 [that] A. R. Hirst, then State Highway Engineer, and I discussed the establishment of a State Trunk Highway system to be marked and maintained by the State with State funds. During that year and the next we had our division engineers select and recommend the roads to be included in such a system of 5,000 miles. This was the first such system to be chosen in any State. The succeeding legislature, 1917, enacted the statute authorizing this system and a joint Legislative committee to hold hearings in every county and make the final selection of the system.
>
> Early in the thinking of this system in 1915, Hirst conceived the idea of markers and [of] giving numbers to the routes instead of the symbols always used before that. The marker was chosen of a form that would have no obvious "bulls-eye" and so on. The form selected was the inverted isosceles triangle still used. This numbering of highways was such a simple direct thing to do that it was adopted by other States in a short time and roads began to be numbered in England and Australia within three years or so.
>
> Another interesting item of early highway marking was the painting of a white center line to keep traffic in proper lanes. This was first used by the Marquette County, Michigan, Highway Engineer, Sawyer. . . .
>
> To return to numbering—we selected the numbers for highways on their general direction. East–West highways I believe were given odd [even?] numbers. This has since been departed from in many cases.

I was later a member of the committee appointed by the U. S. Bureau of Public Roads to select [highways for] a national highway system and give them numbers. We used the same system of odd numbers for N–S and even for E–W highways.

The shield-shaped marker used on the Federal System was submitted by Wisconsin and adopted.

That early 5,000-mile system in Wisconsin was almost entirely dirt road, but the State paid the counties to grade them and use the "split log drag" and steel graders on them so that they were *usually* passable and *always* you knew you were on the right road even though you were stuck in the mud.

In 1918, following the end of hostilities in Europe, the improvement of the U. S. highways became one of the primary activities of both State and Federal highway agencies. The automobile was accepted as a more-or-less reliable vehicle, having been well tested during military activities, and it could be counted upon for long trips without excessive mechanical trouble. During the war period tires also had been greatly improved, so that they could be depended on to stand comparatively hard usage.

The oil companies, alert to see that increased sales of gasoline and oil were predicated on increased travel and the establishment of more distribution points, concentrated their efforts toward more service and filling stations, meanwhile taking advantage of the road map as a means of advertising and promoting their products. In 1923 the oil companies conceived the idea of giving a purchaser of gasoline a road map to aid him in finding his way. Thus, the direct sale of such maps by the mapmaker to the motorist began to decline, except for the complete U. S. State road atlas for which there is a continuing popular demand. The American public is now so thoroughly imbued with the idea that road maps are and should be furnished free that mapmakers have entirely discontinued the sale of individual State maps. Today, the various oil companies distribute free more than one hundred million road maps annually, and partly as a result their yearly gasoline sales have increased in the past half-century from an almost negligible amount to about one billion barrels.

The first complete set of U. S. State road maps was published by Rand McNally & Company in 1922, a project which had been launched 5 years previously.

It was during this period that the first copyright infringement of a road map occurred. The following is from a Missouri newspaper clipping of that period:

> Edwin R. Domick, publisher of a motor road guide for Missouri and Kansas, was fined $250 and assessed the court costs and attorney's fees yesterday by Judge Arba S. Van Valkenburgh in the Federal court for an infringement of a copyright held by Rand McNally & Company.
>
> Domick issued a road guide for Eastern Kansas, Missouri, and Western Illinois. The inclusion of the Illinois map in the guide was an infringement of their copyright, Rand McNally & Company contended, and asked that Domick be restrained from further publication of the guide. Judge Van Valkenburgh granted the injunction.

During the early twenties, simultaneously with the efforts of the oil companies to increase distribution facilities, another great program to aid the motoring public was receiving national attention. This was general road improvement and the planning of a great U. S. highway system. To make all roads "all-weather roads" became a veritable slogan, and all legislative bodies, both State and Federal, were adopting plans and making funds available to carry out the necessary work.

The Federal highway system really started in San Francisco in 1924 when, at a meeting of the American Association of State Highway Officials, a resolution was passed requesting the Secretary of Agriculture to set up a joint board of State highway officials and others appointed from the Bureau of Public Roads.

The Secretary appointed such a board on March 2, 1925, and the 21 State members and 3 Bureau of Public Roads officials held their first meeting on April 20 of that year. At that meeting they formulated and adopted a set of rules and procedures for a discussion of a U. S. highway system, and recommended that 6 regional meetings be held and that all 48 States be included.

In August 1925, as a result of these sessions, a U. S. system of roads totaling 50,137

miles was recommended. The recommendations of the Board were then referred to the various States for consideration, and after their study was completed the total had been raised to 75,884 miles. The Secretary of Agriculture then turned over the whole task of initiating and maintaining the plan to the American Association of State Highway Officials. Standardization of signs and other markings for the highways was also recommended at this time.

That the Federal plan did not meet with universal approval is, of course, understandable. Various organizations were opposed to it for business reasons; in this connection Mr. Brink submitted the following report to the Company in September 1925.

Mr. James, of the Bureau of Public Roads, Washington, D. C., came in to see me this morning. He had a preliminary layout for the numbering system of the U. S. Interstate Highways which I checked over, finding several errors in his lineup and many duplications.

Train organizations everywhere are fighting the new scheme of the Bureau of Public Roads for designing a uniform road plan that will be national in scope and uniformly identified.

Various large Trail and Highway Associations are raising a howl in Washington about the new plan and have exerted Congressional influence to defeat or modify the scheme that has been so far outlined. Of course, a lot of these highway officials are working to save their own jobs and do not relish losing the advertising that goes with their road maps.

Rand McNally & Company has been very enthusiastic about the plan, and I have marked up several sets of maps and submitted them to Mr. James for a numbering scheme. We have cooperated in every way possible in furtherance of the project. It would be a great benefit to us for we have the only complete set of road maps in the U. S. on which the new numbers will first appear. It will lessen the ever confusing problem of showing trails on our maps. In many instances they are unreliable as to the extent of route and markings.

By 1950, the U. S. highway system, constructed with State and Federal funds and under the guidance of the American Association of State Highway Officials, totaled between 160,000 and 165,000 miles. The Association cannot legally enforce any of its requests and recommendations, all its results are based on voluntary acceptance and cooperation.

* * *

Lowest Point in the United States

Topographic mapping parties of the Geological Survey operating in Death Valley during the past winter established elevations indicating that the lowest spot in the United States is 2 feet lower than the previously accepted value. The general location has not changed, however, it being just west of Badwater, Calif., where a Geological Survey bench mark, established in 1937, shows an elevation of 279.324 feet below sea level. This is still the lowest bench mark recorded in more than 70 years of mapping by the Survey.

During recent surveys of the area, engineers of the Geological Survey found that the 280-foot contour below sea level extended about 6 miles to the northwest of Badwater and included an area of about 10 square miles. The lowest elevation determined within this area was −281.9 feet. The Bennetts Well quadrangle, scheduled for publication in the near future, will show this location as a spot elevation of −282 feet about 4 miles west and 1 mile north of the bench mark at Badwater. The new Furnace Creek quadrangle adjoining this sheet to the north will show another spot elevation having the same value about 3 miles north of Badwater and ½ mile west of the road.

Topographic engineers engaged in this work offered the conjecture that the rough surface of salt comprising this locality may actually be in effect floating on the water (or brine) beneath. This water level is only about 3 feet below the surface and varying stages of the water-table could presumably affect the elevation of the floor of the valley.—*The Military Engineer,* September–October 1952.

Cartography and the Centennial of the American Geographical Society

By O. M. MILLER
AMERICAN GEOGRAPHICAL SOCIETY

THE American Geographical Society of New York is a non-profit research organization, and within the geographical field its research is broad. It varies from regional and systematic studies to the development of surveying and cartographic techniques, notably in the fields of photogrammetric reconnaissance mapping and map projections. To give a few examples, the Society is now making an intensive regional study of Finland, conducting a long-range systematic project connected with the relationship of glacier movement and climatic change, and has instituted an extensive research program in medical geography. As a background for this work and its other activities the Society maintains the largest private geographic library and map collection in the Western Hemisphere and, I understand, the third largest in the world, comprising at present between 200,000 and 300,000 maps, 3,000 or more atlases, and some 130,000 books. It publishes a quarterly, the *Geographical Review,* which for nearly 36 years has been one of the world's most influential instruments for the dissemination of the results of geographic research—research undertaken not only by professional geographers but by many others in related fields. It also issues two other periodical publications—*Current Geographical Publications,* a bimonthly listing of new books and articles dealing with geographic subjects, and *Focus,* a new monthly in pamphlet form designed to give geographic interpretation of significant events in the news. Since 1915 the Society has published more than 80 books on a wide variety of subjects—*Focus on Africa; Chile: Land and Society, Pioneer Settlement;* and *New England's Prospect*—to give a few typical titles. One of the latest is *World Geography of Petroleum,* a symposium by leading authorities on the subject. In addition to about 120 black-and-white page map illustrations a year, the Society also produces separate sheet maps, mostly in color. Some 500 of these have appeared to date, most of them in the last 40 years.

In 1852 when the Society was founded, large regions of the world were unexplored. Contemporary maps show areas in this category even in the United States. Consequently, much of the work of the Society in the first 50 or 60 years of its existence, besides building up its collections, consisted in publishing accounts in which emphasis was given to discovery and exploration. Returning explorers lectured to the Society and these lectures were brave occasions, widely attended and often fully reported in the press. The Society also frankly operated as a pressure group in attempting to influence the Federal and State Governments in worthy causes, such as the establishment of a department of geography in the Library of Congress.

Dr. Isaiah Bowman was director of the American Geographical Society from 1915 until 1935, when he became president of Johns Hopkins University. He converted the Society into the research institution it is today and, in addition, instituted cartography as an extremely important part of its activities.

Three aspects of the Society's cartographic work strike me as particularly noteworthy. One is reconnaissance mapping and surveying; another is the development of the art of illustrating articles and books dealing with geographic subjects with simple black-and-white maps; and the third, perhaps the most important, is the extensive work that the Society has done in compiling maps of large areas at small scales from widely diverse sources.

Presented at the Twelfth Annual Meeting, American Congress on Surveying and Mapping, Washington, D. C., June 11-13, 1952.

The Society has, of course, always been active in expeditionary work and has also contributed in the development of techniques of exploration. For instance, as far as concerns reconnaissance surveying on the ground, it was the first in the United States to buy and use the modern type of European theodolite. In the middle twenties it experimented with light-weight planetable equipment and used paper-mounted aluminum sheets and light-weight aluminum frameworks instead of the old heavy wooden planetable boards. It also used at that time light-weight radio receiving sets to receive long-wave time signals. Such equipment weighed only 25 pounds, including dry batteries. In those days other expeditions used equipment that required two or three mules to carry it.

The Society was a pioneer in the use of aerial photography on expeditions and in the compilation of reconnaissance maps from the resulting photographs. It has been particularly interested in the development of mapping methods from "high oblique" photographs. Its first map actually constructed in this way showed the Queen Maud Mountains compiled from photographs taken during the first Byrd Antarctic Expedition Perhaps the most important experimental work in this connection was a survey of northernmost Labrador from "high oblique" photographs taken on the Forbes-Grenfell Expedition of 1931. An area of 5,000 square miles or so was mapped, a large part of it at a scale of 1:100,000 with a 50-meter contour interval. In this work new instruments and techniques were developed. An unusual problem arose when the Society attempted to construct maps from Leica photographs taken more or less at random by Lincoln Ellsworth during his Antarctic flight in 1935. There was no ground control at all, and the resulting sketch maps were published with a good deal of trepidation. A few years later, a British party surveyed this region on the ground and found such striking general agreement between the sketch-maps that had been made from the Leica photographs and their own surveys, that they went to the trouble of republishing their surveys with our maps superimposed.

The difficult but useful art of sketching at small scales from large-scale aerial photography has also received attention. An outstanding recent example is the map of the Orinoco-Ventuari region in Venezuela. Details were sketched by eye from trimetrogon photographs directly upon a radial-line control plot which had previously been reduced to the scale of 1:500,000.

The black-and-white maps which illustrate the texts of most of the Society's publications have to be planned and designed with exceptional care in order to place the proper emphasis on the technical matters under discussion. There is little or no repetition in this kind of map. Each map requires special treatment and the solving of special problems. In my opinion the Society has developed this technique—it might almost be called an art form—to a high state of perfection, as evidenced by the large number of requests for reprints of many of these maps.

Finally, we come to the compiled small-scale map of general or special utility. Before I summarize the work accomplished, a few general remarks on this subject are needed. Many of you are engineers, accustomed to making large-scale surveys at a specified order of accuracy. A compiled map at a small scale must be a reduction from such surveys or from whatever else is available at large scales for the region covered.

Some of the problems and tasks are:

(1) Since by no means all the detail appearing on the large-scale maps can be included on the small-scale map, the fundamental and often difficult problem of selection must be met.

(2) Whatever is selected must often be exaggerated or generalized. Generalization introduces many hazards. It is a craft mastered only after long experience. In my opinion not enough has been written on this difficult subject. Authors of textbooks on cartography tend to avoid getting down to business in this connection.

(3) The region being mapped, if large, will probably not have been consistently surveyed according to engineering standards. The compiler should indicate this, but it is difficult to do so adequately on the map itself without some additional explanation in the margin. Unfortu-

nately, the uninitiated map user accepts as accurate almost anything on a map, provided it is neatly drawn, has legible typography, and is nicely colored.

(4) In regions where accurate surveys do not exist, the small-scale map usually must be compiled from all kinds of conflicting sources—local and uncoordinated surveys, explorers' compass traverses, missionaries' sketch maps, and the like. This material must be searched out, often a major undertaking Furthermore, when once obtained it needs painstaking analysis and assessment before it can be properly fitted into the map compilation.

So it is evident that the life of a map compiler is not always a happy one. If he has integrity, he is concerned not only with the accuracy of his source material and the accuracy with which it is compiled, but also, and perhaps more so than the topographic engineer, with the resulting map's truthfulness. An untruthful and unsuccessfully compiled map reflects sins of commission and omission and, I might also add, sins of inclusion. Who hasn't been exasperated by a map so cluttered with detail as to be well nigh illegible?

Although the American Geographical Society has done fundamental compilation in the polar regions and elsewhere, its greatest accomplishment has been in its maps of the Americas, especially Latin America. The map of Latin America, at the scale of 1:1,000,000, conforming to the standards of the International Map of the World, consists of 107 sheets. To complete the first edition of this map took 25 years and cost approximately half a million dollars. The source material was widely scattered and varied enormously in accuracy or lack of it. Hundreds of different original sources were used on each of many of the sheets. The Society was the first to include on each sheet a reliability diagram of source material, a practice now standard for the official International Map. Many of the sheets are being revised to include the many new surveys made since the first compilation. The 1:1,000,000 series of Latin America greatly facilitated the production of the Society's map of the Americas at the scale of 1:5,000,000 and a soon forthcoming map at the scale of 1:12,500,000. These last two are on a specially devised bipolar conic conformal projection which reduces scale departures close to the minimum possible on any map that includes both North and South America.

So great is the variety of compiled maps of a special nature published by the Society that I cannot attempt to describe them. They range from vegetation maps to such curiosities as maps showing the legal systems of the world. An especially noteworthy series is now being published in connection with the Society's program of medical geography. The five maps already issued deal with polio, cholera, malaria vectors, helminthiasis (worms), and dengue and yellow fever. Quite apart from their content, they are interesting because a new world map projection has been used, a variant of the tilted Aitoff which gives an excellent representation of the relationships between the land masses of the world. This projection was developed by William Briesemeister, senior cartographer of the Society, who incidentally has been on its staff for 40 years.

It may interest you to know that a small exhibit has been prepared in the Society's building in New York City as part of the Centennial celebrations. A comparatively large section of it briefly spotlights some of the milestones in the development of cartography and its relation to geography in the making. And this brings me to my final point. The opening caption of the exhibit reads:

> Geography permeates the sciences of nature and of man, and maps are its essential documents. Maps are not merely graphical records of the positions of places and the distribution of things but are the tools for the analysis of complex geographical facts and form the framework without which many of man's researches and endeavors would be fruitless.

Mapping, in other words, is not an end in itself, but a means to larger ends.

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CURRENT SURVEYING AND MAPPING LITERATURE

MAGAZINE ARTICLES

GEOGRAPHICAL BULLETIN. Published by the Geographical Branch, Department of Mines and Technical Surveys, Ottawa, Canada. No. 1, 1951. (Contains studies by members of the Branch and geographers commissioned by it to accomplish special projects. Format resembles that of the *Geographical Review* of the American Geographical Society.)

REIHE A: HOHERE GEODASIE (SERIES A, HIGHER GEODESY). Veroffentlichung Nr. 1, (Publication No. 1). Published by the Deutsche Geodatische Kommission (German Geodetic Commission) and transmitted by the Institut fur Angewandte Geodasie (Institute for Applied Geodesy). 1951.

THE FEDERAL CITY IN 1793. Frederick R. Goff. *The Library of Congress Quarterly Journal of Current Acquisitions*, Vol. 9, No. 1, November 1951. (Discussion of a first edition of Tobias Lear's "Observations on the River Potomack," New York, 1793, annotated by James Kent with a description of his trip from New York to Georgetown, Washington, and Alexandria in 1793–94. This edition has as a frontispiece a "Plan of the City of Washington" engraved by Thackara and Vallance, and the article goes into the history of the engraving of the various plans taken from the Ellicott version of the L'Enfant Plan.)

A RADAR SURVEY OF THE ICE BARRIER. Lieutenant R. G. Higgins. *The Journal of the Institute of Navigation*, Volume V, Number 2, April 1952. (Describes methods and results of radar survey made by the Norwegian ship "Norsel" on its last relief expedition to Queen Maude Land in the Antarctic.)

PROGRESS IN OCEANOGRAPHICAL RESEARCH. G. E. R. Deacon, Director, the National Institute of Oceanography. *The Journal of the Institute of Navigation*, Volume V, Number 2, April 1952. (Historical discussion of the general trend of oceanographic research, naming the outstanding contributors.)

SOME ASPECTS OF MATHEMATICAL GEOGRAPHY. J. E. R. Ross, Dominion Geodesist. *The Canadian Surveyor*, Vol. X, No. 12, April 1952. (Outlines some of the problems and results of geodetic surveys in relation to geography.)

THE PROBLEM OF EDUCATION FOR THE SURVEYORS AND PHOTOGRAMMETRISTS OF THE FUTURE. Prof. G. H. Harding, with a discussion of the paper by J. A. H. Church. *The Canadian Surveyor*, Volume X, Number 12, April 1952. (Outlines the case for a stronger surveying and mapping curriculum in colleges and universities.)

THE WORK OF THE INTERNATIONAL HYDROGRAPHIC BUREAU. Vice-Admiral J. D. Nares. *The Journal of the Institute of Navigation*, Volume V, Number 2, April 1952. (Describes the organization, objectives, publications, etc., of the Bureau.)

THE SARGASSO SEA. *Hydrographic Bulletin*, Number 25, June 21, 1952. (Number 138 in a series of questions and answers appearing irregularly in the Bulletin. Provides historical and factual data on this legendary phenomenon.)

THE HISTORY OF A RIVER. Raymond E. Janssen. *Scientific American*. (Traces the course and explains the geological processes which obliterated the ancient Teays River which cut across the North American continent millions of years ago. A portion of its course is now used by the Ohio River system.)

PANEL ON IMPROVING AERIAL MAPPING PHOTOGRAPHY. Eldon D. Sewell, Chairman and Moderator, at the 18th Annual Meeting of the American Society of Photogrammetry. *Photogrammetric Engineering*, Volume XVIII, Number 3, June 1952. (Address on the subject by Mr. Sewell, followed by panel discussion.)

ADJUSTMENT OF EUROPEAN TRIANGULATION. C. A. Whitten, U. S. Coast and Geodetic Survey. *Bulletin Geodesique*, Nouvelle Serie, Annee 1952, No. 24, 1er Juin 1952. (Technical details and summary of results obtained in adjustment of the Southwestern and Northern areas. Paper presented at the general assembly of the International Geodetic Association at Brussels, accompanied by tables. In English, with summaries in German, Spanish, French, and Italian.)

ARMY SETS NEW MAP-MAKING RECORD. (News item.) *Army-Navy-Air Force Register*, Volume 73, No. 3788, July 12, 1952. (Describes the quality and quantity of maps produced by the Army Map Service.)

INCREASING THE SAFETY OF THE WORLD'S SHIPPING. Comdr. Leonard S. Hubbard, U. S. Coast and Geodetic Survey. *The Department of State Bulletin,* Volume XXVII, Number 681, July 14, 1952. (A report on The Sixth International Hydrographic Conference held at Monte Carlo, Monaco, from April 29 to May 9, 1952. Includes a discussion of the work of producing nautical charts.)

A TECHNIQUE FOR CONSTRUCTING A POPULATION AND URBAN LAND USE MAP. William Applebaum. *Economic Geography,* Volume 28, Number 3, July 1952. (Revision of a paper first presented before the Association of American Geographers in December 1935 by a pioneer in marketing geography.)

CADASTRAL SURVEYS ON PUBLIC LANDS. Earl G. Harrington. *Our Public Lands,* Volume 2, Number 3, July 1952. (Discusses the fundamental necessity for accurate surveys in the administration of the Nation's public lands and the value of those surveys in the national mapping program.)

CONTROLLING OREGON SAND DUNES. Leon R. Nadeau. *Our Public Lands,* Volume 2, Number 3, July 1952. (Tells of organization of Siuslaw Soil Conservation district and describes method of controlling dunes which threatened to choke Siuslaw River and ship channel.)

EARLY UNITS OF MEASUREMENT AND THE NAUTICAL MILE. Commander Alton B. Moody, USNR, *The Journal of the Institute of Navigation,* Volume 5, Number 3, July 1952. (Historical discussion of the subject and definition of the U. S. nautical mile compared with the British nautical mile.)

GRAVITY MEASUREMENTS AT SEA, 1948 AND 1949. J. L. Worzel and Maurice Ewing. *Transactions, American Geophysical Union,* Volume 33, Number 3, July 1952. (Describes work done during the years named, using instruments on board U. S. Navy submarines.)

THE DEVELOPMENT OF ARMY MAPPING. Colonel J. G. Ladd, Commanding Officer, Army Map Service. *Army Information Digest,* Vol. 7, No. 7, July 1952. (A brief article that traces the history of Army mapping and provides some startling statistics on its present magnitude.)

THE ORIGIN OF OCEAN CURRENTS. J. Crease. *The Journal of the Institute of Navigation,* Volume 5, Number 3, July 1952. (Discussion of various theories as to the origin and mechanics of ocean currents throughout the world.)

THE PRICELESS SANTA FE RECORDS. Guy P. Harrington and George H. Well. *Our Public Lands,* Volume 2, Number 3, July 1952. (Describes content of the archives of the Santa Fe Land and Survey Office which includes priceless original documents, court records, etc., relating to the Spanish and Mexican land grants in southwestern United States.)

NATHANIEL BOWDITCH—GREAT NAVIGATOR—GREAT AMERICAN. Maclean Kirkwood. *The Ensign,* Volume XL, Number 6, July–August 1952. (Brief tribute to the noted scholar, cartographer, and mathematician.)

CHALLENGES FACING THE WORLD'S SCIENTISTS. John D. Hickerson, Assistant Secretary of State for U. N. Affairs. *The Department of State Bulletin,* Volume XXVII, Number 686. August 18, 1952. (Address before the 17th International Congress of the International Geographical Union, August 8, 1952.)

COMPTES RENDUS DES SEANCES DE TRAVAIL DE L'ASSOCIATION INTERNATIONALE DE GEODESIE DE LA SECTION DU GEOIDE. Brigadier G. Bomford, Secretary of Section V, Geoid. *Bulletin Geodesique,* Nouvelle Serie, Annee 1952, ler Mars 1952, No. 23. (Provisional General Report on *Earth Tides* by Dr. W. D. Lambert, followed by various other reports and discussions during the five meetings of the section.)

CONTOURS OF THE GEOID FOR SOUTHEASTERN CANADA. C. H. Ney, Chief, Triangulation Adjustments Division, Geodetic Survey of Canada. *Bulletin Geodesique,* Nouvelle Serie, Annee 1952, ler Mars 1952, Number 23. (Describes procedure for adjusting results of gravity observations and plotting geoidal contours. With maps and tables.)

BOOKS AND PAMPHLETS

GEOLOGY OF THE CONTINENTAL SLOPE OFF CENTRAL CALIFORNIA. G. Dallas Hanna. *Proceedings of the California Academy of Sciences.* Volume XXVII, Nos. 9, 10, July 11, 1952.

CONFORMAL MAPPING. Zeev Nehari. 396 pages, diagrams. *McGraw-Hill Book Company, Inc.,* New York. 1952. (The material is presented so as to serve as a college text book for a beginning course in Conformal Mapping. A good working knowledge of advanced calculus is required for a complete understanding of the text.)

—LYMAN D. LYNN

DISTINCTIVE RECENT MAPS

For the reader's convenience, the addresses of publishers and prices of maps are given where this information is available.

—EDITOR

Wirtschaft der Erde is the title of a new and comprehensive economic map of the world, published in 1951 by the Karl Wenschow firm of Munich, Germany. The map is printed on four sheets each measuring 34 by 49 inches. When joined and mounted they form a large wall map 68 by 98 inches. The scale is 1:15,000,000. Economic data shown on this map and production graphs are based on 1948–49 statistics.

The Color-Graphic Map of the United States presents a new use of color and shading to portray relief. The predominant ground color is approximated on the map, and land forms are depicted by appropriate shading. The map is described by the publisher (Jeppesen and Company of Denver, Colo.) as "the map you feel with your eyes." The map is at the scale of 1:3,000,000 and measures 38 by 58 inches. Cartography is by Hal Shelton. The "Collector's Edition" of the map is listed at $11.95.

Transmission System of Tennessee Valley Authority is the title of an electric power map published in 1951 by the Division of Power, Tennessee Valley Authority. It shows transmission lines "in service," "under construction or authorized," and "to be retired," as well as generating plants, substations, and interchange points. Property of the T.V.A., wholesale contractors, and private utilities, and service areas of cooperatives and municipalities are delimited. The map is colored and measures 33½ by 53½ inches. The map is at the scale of 12 miles to 1 inch.

Prof. Guy-Harold Smith of Ohio State University has compiled and published a new (1952) *Population Map of Ohio*, based upon 1950 census statistics. Distribution of rural population is shown by dots on this black-and-white map, each dot representing "twenty-five rural inhabitants localized by civil townships." City and village populations are indicated by graded representatives of spheres. The nine gradations range from 200–1,000 up to 1,000,000. The map is at the scale of 1:1,000,000 and measures 18 by 16½ inches.

A facsimile, in color, of *Washington's Official Map of Yorktown*, at the time of Cornwallis' surrender, was issued in 1952 by the National Archives (Washington, D. C.) as No. 21 in its facsimile series. The map measures 19 by 15 inches. It is accompanied by five pages of descriptive text, and is folded in an attractive cover. The original map (in the collections of the National Archives) from which the facsimile was made, is dated October 29, 1781, and bears the signature of Lt. Col. Gouvion. Actual drawing of the map is assumed to have been carried out by a draftsman in the Engineer unit commanded by Gouvion. The original map measures 38 by 29 inches and was drawn at the approximate scale of 370 feet to 1 inch. The facsimile map with text is for sale, at 75 cents, by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Roy Wenzlick and Company of St. Louis recently published a facsimile of a 1717 map of the lower Mississippi region. Entitled *Amplissimae regionis Mississippi*, the original map was prepared as part of a publicity campaign to promote the French Company of the West (also known as the Mississippi Company). The facsimile map is colored, and measures 18 by 21 inches. It is at the scale of 1:7,300,000. The verso carries a descriptive note under the heading "The Greatest Land Promotion in All History."

The Geological Survey of Canada and the Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada, have collaborated in the preparation of a map showing *Principal Coal, Iron Ore, and Iron and Steel Areas in Relation to the St. Lawrence Seaway*. Published in 1952, this colored map measures 19 by 16 inches and is at the scale of 1 : 16,000,000. The map covers a large segment of the Western Hemisphere, including eastern Canada, the United States east of the Rocky Mountains, Mexico, Central America, and South America north of the Equator. Coal bearing regions, iron ore deposits, and steel manufacturing centers are indicated by appropriate color designations. Coal markets in Ontario and Quebec are numbered and keyed to a marginal table which gives 1950 consumption figures. Iron ore shipments and steel consumption figures for various areas are also shown in the statistical tables.

"New France," or Canada, of the seventeenth and eighteenth centuries, is illustrated on a pictorial-historical map published recently by Donald G. Bouma of Goshen, Ind. The map bears the French title *Carte Partie Occidentale de la Nouvelle France ou Canada comme elle fut en* XVII^{e} *et* XVIII^{e} *Centuries dans l'Amerique du Nord*. It is at the scale of 1:4,500,000 and measures 18 by 23 inches. The map may be ordered from the publisher at $1.00 per copy, plus postage. It is printed in soft colors on simulated hand-made paper.

The Governor of Puerto Rico and the Insular Departamento del Interior published in 1951 a new relief map entitled *Puerto Rico e Islas Limitrofes*. The map is at the scale of 1:120,000, with

relief portrayed by contour lines at 50-meter intervals. It measures 27 by 62½ inches. Internal political divisions are also shown on the map, as well as highways (in five classifications), towns and cities, and civilian and military airports. Inset maps show outlying islands of the Commonwealth. The map, which was compiled and printed by the U. S. Geological Survey, is based upon the 1:30,000 scale topographic map series of Puerto Rico.

Mapa de Regiones Agricolas de Costa Rica is the title of a new agricultural map of that country. Based on 1950 census figures, the map was published at San Jose, C. R., in 1952 by the Ministerio de Economía y Hacienda, Dirección General de Estadística y Censos. This colored map is at the scale of 1:1,350,000 and measures 14 by 20 inches. Fifteen agricultural regions, based on principal crops or crop combinations, are differentiated. A marginal table gives, by regions, the number of farms, the areal extent (in "manzanas," i.e., 100 square yards), and the number of rural families per "manzana."

Joseph Pilsudski, of Northwestern University, has prepared and published (1952) a *Physical Map of Bolivia*. The technique employed to depict land forms is similar to that popularized by Erwin Raisz and A. K. Lobeck. At the scale of 1:3,700,000, the map measures 25 by 22 inches. A profile, running approximately along the 18th parallel south, appears below the map proper.

An *Ekonomisk Karta över Europa*, compiled by W. William-Olsson, was published in 1952 by the Generalstabens Litografiska Anstalts Förlag of Stockholm, Sweden. The map is on the Albers equal-area projection, and is printed on two sheets each measuring 53 by 35 inches. The scale is 1:3,250,000. Arable land, forests, meadows and nonproductive land, as well as railways, rivers, and canals, are shown. Political boundaries as of 1951 are indicated, with the exception of unsettled frontiers which are shown as of 1937 or 1945. "All agglomerations with more than 10,000 inhabitants are marked on the map and classified on the basis of the occupations of the population . . ." Local production is subdivided into "Industry and Handicrafts" and "Service," the latter comprising all branches except industry and handicrafts. The Economic Map of Europe is available in the United States from Rand McNally & Company, Chicago, Ill.

Soils of Germany are mapped on the *Bodenkarte der Deutschen Demokratischen Republik*, published in 1951 by the Institut für Bodenkartierung, Ministerium für Land- und Forstwirtschaft der Deutschen Demokratischen Republik. It was printed at Sachsenverlag, Dresden. The *Bodenkarte* measures 45 by 31 inches and is at the scale of 1:500,000. Seventeen color-symbol combinations distinguish soil types and uses. A 28-page text entitled "Bodenkunde und Bodenkultur," prepared by Prof. Dr. Hermann Stemme, accompanies the map.

Distribuição da População de Portugal 1940 is the title of a new population map of that country. It was published in Lisbon in 1951 by the Instituto Para Alta Culturas, Centro de Estudos Geográficos, and printed by the Instituto Geográfico e Cadastral. The map is on two sheets which, when joined, measure 53 by 35 inches. The scale is 1:500,000. In addition to population distribution and densely settled areas, the map shows regions over 700 meters in elevation, as well as wooded and sandy areas. There is an inset map of Porto and environs at the scale of 1:250,000.

An interesting group of nine population maps of England and Wales was published by the Maps Office, Ministry of Housing and Local Government in London, January 1952. Each is colored, measures 13 by 8 inches, and is drawn at the scale 1:3,250,000.

Fig. 1 shows "Population Losses in Rural Districts 1921–47."

Fig. 2 shows "Generalized Changes in Total Population 1921–47." and distinguishes three areas: (*a*) Regions of decrease, mainly persistent, (*b*) regions of persistent increase, and (*c*) areas of recovery, mainly 1939–47 (recent increase following previous decrease).

Fig. 3 shows "Persistent Population Increase 1921–31, 1931–39, 1939–47" and distinguishes rural and urban areas.

Fig 4 shows "Persistent Population Decrease 1921–31, 1931–39, 1939–47."

Fig. 5, entitled "Population Recovery Since 1939," shows areas of former loss which have or have not regained their populations since 1939."

Fig. 6, "Population Losses 1921–47," distinguishes rural and urban areas losing since 1921, since 1931, and since 1939.

Fig. 7, "Changes in Population by Migration 1921–47," shows: (*a*) Regions of loss, mainly persistent, (*b*) regions of persistent gain, and (*c*) areas of recovery, mainly 1939–47 (recent gain following previous loss).

Fig. 8, "Volume of Population Change 1931–51," contrasts areas of increase and areas of decrease. The County of London is shown as an inset.

Fig. 9, "Attraction to Town and Country," shows comparative rates of population increase 1939–47 in three categories: (*a*) "Greater to towns," (*b*) "greater to country," and (*c*) "fairly even." Areas of loss in both town and country are uncolored.

The Touring Club du Congo Belge published in 1952 a *Carte Routière du Congo Belge et du Ruanda Urundi*. This transportation map was printed in Brussels by Etablissements Cartographiques E. Patesson, 45, rue Ed. Michiels. The scale is 1:2,000,000. Two sheets (North and South) each measure 22 by 43 inches.

Roads (with distances), railroads, airlines, navigable rivers, radio beacons, airports, and internal political divisions are indicated. An accompanying pamphlet includes a comprehensive place name index, a list of hotels, advice for motorists, and general tourist information.

Forty different Moroccan soil types are mapped on *Esquisse Preliminaire de la Carte des Sols du Maroc*. It was compiled by Wladimir Cavaller and published at Rabat, Morocco in 1950 by the Direction de l'Agriculture, du Commerce, et des Forêts du Maroc. The map is colored and is at the scale of 1:1,500,000. Dimensions are 25 by 36 inches.

The *Depth Curve Chart of the Adjacent Seas of Japan* demonstrates a new technique of portraying relief by combining contours and hachures. The method, originated by Prof. Tanaka, is described by him in an article published in the July 1950 number of the *Geographical Review*. The *Depth Curve Chart* was published in 1952 by the Maritime Safety Agency in Tokyo. It measures approximately 30 by 40 inches and is at the scale of 1:8,000,000. Place names are given in Japanese and English.

—Walter W. Ristow
—Marie C. Goodman

New Map of the Pacific Northwest

W. Elliott Judge, of San Francisco, has recently published a wall map of the Pacific Northwest including the five States of Washington, Oregon, Idaho, Montana, and Wyoming.

The map is lithographed in color with State and county boundaries shown in blue, railroads in black, and State and Federal highways in red. Equipped with metal rods top and bottom and ready to hang up on a wall, the map measures 54 inches in width and 39 inches in height. Cities and towns of 200 population or over are correctly located on the map and are listed in an alphabetical index by States with cross lines index for their immediate location.

The map is priced at $15.00 and can be obtained by writing to W. Elliott Judge, 814 Montgomery St., San Francisco 11, Calif.

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Books in Review

HIGH, WIDE AND DEEP. John J. Floherty. *J. B. Lippincott Co.*, Philadelphia, Pa. 1952. 154 pages. $2.75.

High, Wide and Deep is one of a series of career books by this author; in this book he attempts to describe the many and varied activities of the U. S. Coast and Geodetic Survey in the language of the layman—clear and free from long technical and scientific explanations.

The first chapter discusses the history of the Coast Survey, how it was established, and who the men were who planned the scope of its work.

After this introduction the functions of the various divisions are dealt with—Tides and Currents, Coastal Surveys, Geodesy, Geomagnetism and Seismology. The descriptions center primarily around the field activities of these branches and consist of a conversational "question-and-answer" style which is reminiscent of a type of Victorian literature in which Uncle John or Aunt Elizabeth gave their nieces and nephews a complete education in natural history or geology by answering their questions and furnishing them with long and detailed explanations.

A serious omission in the book is that practically no mention is made of the Survey's extensive mapmaking division. Thousands of charts showing our coastal waters, as well as special charts for aerial navigation and numerous miscellaneous maps, are printed annually. It is almost solely through these aids that the public understands and appreciates this efficient bureau of the Department of Commerce.

Students desirous of knowing whether they wish to join the Coast and Geodetic Survey, and others who may be interested in its operations, will find this book both accurate and informative.

HELMUTH BAY

Rand McNally & Company

PLANE & GEODETIC SURVEYING (Volume 2, 4th Edition). David Clark. Revised and enlarged by James Clendinning. *Constable & Company, Ltd.*, London. 1951. 582 pages. 32s./6d.

This fourth and revised edition is a text on geodetic surveying which deserves a wider use in the United States. A particularly outstanding aspect of this book is its liberal use of, and reference to, the periodical literature in the field.

In the 140 pages devoted to astronomy there is a concise exposition of theory and practice; the classical methods and some of the newer methods for position determination (such as those attributed to De Graaf Hunter) are presented in ample detail.

Some 300 pages are devoted to triangulation, traverse, and leveling, with considerable emphasis on the distinctive procedures and equipment used in different countries, including the United States. As this is a recent book, practically all the current geodetic instruments are treated. In fact, appendix IV is a detailed account of the Bergstrand geodimeter, an instrument not yet, but soon to be, used in this country. There is considerable material on the adjustment of observations and on the geometry of the ellipsoid, and a brief discussion of the determination of a datum by geodetic methods is included. There is a detailed discussion of the Transverse Mercator and the Lambert projections but unfortunately nothing on the oblique Mercator (skew orthomorphic on the ellipsoid), a projection which is coming into more general use.

The last part of the book, some 100 pages, is devoted to a more broadly descriptive coverage of Topographic and Reconnaissance Surveying, Map Construction, Radar Ranging, and Triangulation. In addition to the appendix already mentioned, the one on Mechanical Computing by Comrie and the one on the computation of exceptionally long lines are of particular interest these days.

A more comprehensive review may be found in the October 1952 Transactions of the American Geophysical Union.

A. D. SOLLINS

Coast and Geodetic Survey

Faster Computers

Two new electronic calculators, smaller, faster, and with better memories than their predecessors, have just been completed. One is at the Institute for Advanced Study at Princeton, the other at the Los Alamos Scientific Laboratory.

The Princeton machine, which has been six years in development, was designed by a team under the direction of the mathematician John von Neumann. This calculator served as a prototype for the Los Alamos device, which is called MANIAC, for Mathematical Analyzer, Numerical Integrator and Computer. MANIAC can do in 1½ hours a problem which took ENIAC, a more primitive brain, 24 hours. The new computer contains only 3,000 vacuum tubes as against 18,000 in ENIAC.

Von Neumann's calculator is now being applied to problems in meteorology. It is making 24-hour forecasts of the general weather pattern at an altitude of about 18,000 feet over Canada, the U. S., and about one-third of the Atlantic Ocean. In doing this the machine considers weather data from 361 grid points over North America and performs some 1,660,-500 operations on the figures to obtain an hour-by-hour prediction. The designers estimate that when operating at top speed the machine will complete a forecast in 48 minutes. Jule G. Charney, the meteorologist working with Institute scientists on this study, hopes to extend the analysis to about eight levels of altitude and, through the computations made possible by the machine, to learn more about the basic forces underlying our weather, particularly the way in which the sun's heat energy is changed into energy of motion of the atmosphere.—*Scientific American*, August 1952.

MAP INFORMATION

This department was inaugurated for the purpose of bringing to the attention of the members information pertaining to the availability of maps, surveys, etc., with particular emphasis on how such material can be procured. Authoritative articles covering this class of information are solicited. It is believed that through an interchange and dissemination of such information maximum benefits will accrue to the surveying and mapping profession.

—EDITOR

Topographic Maps

THE FOLLOWING quadrangle maps, topographic or planimetric, were published between June 1 and August 31, 1952, by the U. S. Geological Survey. Planimetric maps (no contours) are indicated in the list by the letter (P) following the name. All maps are available with or without the green overprint which indicates woodland. The quadrangle name is shown in capital letters, followed by the county name in upper- and lower-case letters. Since many quadrangle maps extend into several counties, only that county name is given which contains the place for which the quadrangle is named. For example, the quadrangle MINERAL SPRINGS SOUTH, in *Arkansas,* is in parts of Howard, Sevier, Little River, and Hemstead counties, but only Howard is shown because the town of Mineral Springs is in that county.

Maps of areas east of the Mississippi River may be ordered from the Chief of Distribution, U. S. Geological Survey, Washington 25, D. C., and of areas west of the Mississippi River from the Distribution Section, U. S. Geological Survey, Denver Federal Center, Denver, Colo.

Alaska
ANCHORAGE (C-6)*—Third Judicial Division†
ANCHORAGE (D-1)*—Third Judicial Division†
FAIRBANKS (C-4)*—Fourth Judicial Division†
HEALY (B-4)*—Fourth Judicial Division
HEALY (B-5)*—Fourth Judicial Division
JUNEAU (D-4)*—First Judicial Division†
SKAGWAY (A-1)*—First Judicial Division†
SKAGWAY (B-1)*—First Judicial Division†
SKAGWAY (C-1)*—First Judicial Division†
SKAGWAY (C-2)*—First Judicial Division†
TALKEETNA (A-1)*—Third Judicial Division†
TALKEETNA (B-1)*—Third Judicial Division†
TANACROSS (A-5)*—Fourth Judicial Division†
TANACROSS (B-4)*—Fourth Judicial Division†
TANACROSS (B-6)*—Fourth Judicial Division†
TYONEK (C-1)*—Third Judicial Division†
TYONEK (D-1)*—Third Judicial Division

Arizona
HOLY JOE PEAK—Pinal†

Arkansas
HOPE—Hempstead†
LOCKESBURG—Sevier†
LONOKE*—Lonoke
MINERAL SPRINGS NORTH—Howard†
MINERAL SPRINGS SOUTH—Howard
NASHVILLE—Howard
SILVER RIDGE—Sevier

Arkansas-Oklahoma
CERROGORDO—Little River

Arkansas-Oklahoma-Texas
FOREMAN—Little River

California
BENICIA—Solano
BIG PINE*—Inyo
BRAY*—Siskiyou†
CONFIDENCE HILLS*—Inyo
DEVIL PEAK—Placer
DORRIS*—Siskiyou†
DOS PUEBLOS CANYON—Santa Barbara†
EXETER—Tulare†
IVANHOE—Tulare†
LINDSAY—Tulare†
McCOY WASH—Riverside†
POLLOCK PINES—El Dorado†
PORTERVILLE—Tulare
RIVERTON—El Dorado†
ROBBS PEAK—El Dorado
SAN NICOLAS ISLAND—Ventura†
SANTA CRUZ ISLAND A—Santa Barbara†
SANTA CRUZ ISLAND B—Santa Barbara†
SANTA CRUZ ISLAND C—Santa Barbara†
SANTA CRUZ ISLAND D—Santa Barbara†
SANTA ROSA ISLAND EAST—Santa Barbara†
SANTA ROSA ISLAND NORTH—Santa Barbara†
SANTA ROSA ISLAND SOUTH—Santa Barbara†
SANTA ROSA ISLAND WEST—Santa Barbara†
SEARS POINT—Sonoma
SLATE MOUNTAIN—El Dorado†
TUNNEL HILL—El Dorado
WILLOWS—Glenn†
WINGATE WASH*—Inyo

California-Arizona
BLYTHE—Riverside

* Indicates 15-minute quadrangle; all others are 7½-minute quadrangles.
† Indicates map lies wholly within county named.
‡ Indicates availability in either a contour or a shaded-relief edition.

CORNING—Tehama

Colorado
BARNESVILLE—Weld†
DEAD HORSE SPRINGS—Morgan†
GREASEWOOD LAKE—Weld
LEADER NW—Adams†
LIVING SPRINGS—Adams†
MESSEX—Washington
ORCHARD—Morgan†
SOUTH ROGGEN—Weld
SUNKEN LAKE—Morgan†
TAMPA—Weld†
WELDONA—Morgan†
WIGGINS—Morgan†

Connecticut
WOODMONT—New Haven†

Connecticut-New York
SHERWOOD POINT—Fairfield

Delaware-New Jersey
WILMINGTON SOUTH—New Castle

Florida
OAK HILL—Volusia

Georgia
CAMPBELL MOUNTAIN—Lumpkin†

Idaho
GRAND VIEW*—Owyhee

Illinois
TUSCOLA*—Douglas

Indiana
LAFAYETTE—Tippecanoe†
LEESBURG—Kosciusko†
VALEENE—Orange

Kansas
BAYNEVILLE—Sedgwick†
DE SOTO—Johnson
EUDORA—Douglas
OSKALOOSA—Jefferson†

Kentucky
AULT—Elliott
CRAVEN—Nelson
ELIZABETHTOWN—Hardin
GRAHN—Carter†
HEAD OF GRASSY—Lewis†
ISONVILLE—Elliott
MASON—Grant
SONORA—Hardin
WALTON—Boone
WESLEYVILLE—Carter

Kentucky-Tennessee
CAYCE—Fulton
FRANKLIN—Simpson

Louisiana
BAYOU BLANC (P)—Iberia†
BAYOU LUCIEN—Iberia
PITKIN—Vernon
STEEP GULLY—Vernon

Maine
PEMBROKE—Washington†

Massachusetts
CLINTON—Worcester†
GREAT POINT—Nantucket
SQUIBNOCKET—Dukes†

Massachusetts-New Hampshire
ASHBURNHAM—Worcester
ASHBY—Middlesex
PEPPERELL—Middlesex

Mississippi
FOREST*—Scott
PELAHATCHIE*—Rankin

Mississippi-Tennessee
ASHLAND*—Benton
CORINTH*—Alcorn

Missouri
BOSWORTH—Carroll
HERMITAGE*—Hickory
MIAMI STATION—Carroll
WAVERLY—Lafayette

Nebraska
KENNEDY*—Cherry†
POWDERHORN VALLEY*—Cherry†
SIMEON*—Cherry†

Nebraska-South Dakota
CODY*—Cherry
KILGORE*—Cherry
SPARKS*—Cherry
VALENTINE*—Cherry
VERDEL—Knox

Nevada
STILLWATER*—Churchill†

New York
CALEDONIA—Livingston
GENESEO—Livingston†
HARRISVILLE—Lewis
HOLLEY—Orleans
LAKE BONAPARTE—Lewis
MONTOUR FALLS—Schuyler
ONEIDA*—Oneida
STAFFORD—Genesee†

North Carolina
FAIR GROVE—Davidson
GUILFORD—Guilford†
JONES BAY—Pamlico†
LOWLAND—Pamlico
SHELBY*—Cleveland
SOUTH CREEK—Beaufort
SOUTH MILLS*—Camden

North Dakota
TOKIO—Benson

Ohio
WHITEHOUSE—Lucas†

Oklahoma
SHOALS—Choctaw

Oklahoma-Texas
FROGVILLE—Choctaw

Pennsylvania
CARLISLE*—Cumberland
CONRAD*—Potter†

Rhode Island-Massachusetts
PAWTUCKET—Providence

South Dakota
ANGOSTURA RESERVOIR—Fall River†
BURDOCK—Fall River†
CASCADE SPRINGS—Fall River†
EDGEMONT—Fall River†
EDGEMONT SW—Fall River†
HEPPNER—Fall River†
HOT SPRINGS SE—Fall River†
INTERIOR—Jackson
INTERIOR SE—Washabaugh†
POTATO CREEK—Washabaugh†
RUMFORD—Fall River†
WANBLEE—Washabaugh†
WETA—Jackson†

Tennessee
LEBANON—Wilson†
MARTIN—Weakley
TRENTON—Gibson†

Texas
COLORADO CITY SE—Mitchell†
IATAN—Mitchell

Texas-Arkansas-Oklahoma
DANIELS CHAPEL—Bowie

Texas-Oklahoma
SLATE SHOALS—Lamar
WOODLAND—Red River

Utah
CEDAR CITY—Iron†
ENOCH—Iron†

Virginia
BENNS CHURCH—Isle of Wight
DANIELTOWN—Brunswick
GREAT MACHIPONGO INLET—Northampton†
HERNDON—Fairfax
MANASSAS—Prince William
WARFIELD—Brunswick

Virginia-Maryland
PASSAPATANZY—King George

Washington
ALAMEDA FLAT*—Douglas
BOOT MOUNTAIN*—Okanogan
ENDICOTT*—Whitman†
PENAWAWA*—Whitman

Wisconsin-Minnesota
MAIDEN ROCK*—Pierce

Wyoming
CASEBIER HILL—Goshen†
FULLER RESERVOIR—Fremont†
GUERNSEY—Platte
HARRIS BRIDGE—Fremont†

In addition to the standard series of quadrangle maps, reconnaissance maps at the scale of 1:250,000 are being published for both the continental United States and Alaska. Maps in this series published in the period include the following:

Alaska
ATLIN—First Judicial Division†
CHRISTIAN—Fourth Judicial Division†
CIRCLE‡—Fourth Judicial Division†
COLEEN‡—Fourth Judicial Division†
DILLINGHAM—Third Judicial Division
HOWARD PASS—Second Judicial Division†
KILLIK RIVER—Second Judicial Division
LIME HILLS‡—Fourth Judicial Division†
LIVENGOOD‡—Fourth Judicial Division†
MELOZITNA‡—Fourth Judicial Division†
MT. MICHELSON‡—Fourth Judicial Division†
SELDOVIA‡—Third Judicial Division†
TABLE MOUNTAIN‡ — Fourth Judicial Division†
TANANA‡—Fourth Judicial Division†
UNIMAK‡—Third Judicial Division†
WISEMAN—Fourth Judicial Division

CONGRESS NEWS

Report of Property Surveying Handbook Committee of the Property Surveys Division

The Property Surveys Division of the American Congress on Surveying and Mapping has had under discussion for two years the preparation of a handbook on property surveying. The first effort in this direction, under the chairmanship of John P. Goggin of Marathon, Fla., was the study of a possible table of contents. As a result of that work and the ensuing discussions, the Handbook Committee, now under the chairmanship of Sol A. Bauer, 1836 Euclid Avenue, Cleveland, Ohio, reports further progress.

The chairman has appointed a sub-committee consisting of Vernon D. George, 8404 Ramsey Ave., Silver Spring, Md., and Stanley M. Shartle, P. O. Box 56, Danville, Ind., to begin the preparation of a chapter to be called, for the time being, A Manual on Calculations for Property Surveying. Both Mr. George and Mr. Shartle are well equipped for this task, and have been represented in earlier issues of SURVEYING AND MAPPING by articles on calculations developed by them. This sub-committee is now at work defining its field and developing chapter headings, and from there will proceed to the actual matter of writing a comprehensive manual which will present as many solutions of the several mathematical problems of the property surveyor as are deemed suitable. It is planned that other sub-committees will be appointed soon to take up other subjects necessary for the contemplated handbook.

The Committee will welcome any and all calculation methods and short cuts, tables, or innovations that members may have developed in their own practice.

SOL A. BAUER
Committee Chairman

Southern California Section

On August 9, 1952, the Southern California Section of the American Congress on Surveying and Mapping held a meeting in the rooms of the Extension Division, University of California. The program, presented by the Technical Committee of the section, was centered around the subject of drafting instruments and techniques.

William C. Wattles gave a report on the results of the Field Day held on April 26. Lee Lucas, of Los Angeles County, spoke on "The Cartographer in Engineering."

Interesting demonstrations and displays were furnished by the Richfield, Shell, and Standard Oil Companies; the American Association of Petroleum Geologists; and the Automobile Club of Southern California. Local drafting equipment firms, including Chas. Bruning Co., Eugene Dietzgen Co., Keuffel & Esser, A. Lietz Co., and Varigraph, presented a fascinating display of the latest drafting supplies and equipment.

Paul Roth, "pinch-hitting" for E. L. Chapin of the Technical Committee, is credited with organizing this program.

On September 17, members of the section and their guests were entertained in the auditorium of the General Petroleum Corporation with a color motion picture of the ancient Mayan temple ruins and the peoples who live among them now. Giles Healey, who made the film for the United Fruit Company, was present to give many interesting sidelights to his experiences while filming these mysterious ruins.

—FORREST M. BURKE
Secretary-Editor

ACSM Helps Celebrate Centennial of Engineering

The American Congress on Surveying and Mapping was one of 66 engineering organizations which joined hands in celebrating the Centennial of Engineering with a convocation in Chicago, Ill., that brought together 27,964 engineers from all parts of the free world during the period September 3–13, 1952. The occasion provided an opportunity for reviewing the accomplishments of science and engineering during the past century, for taking stock of where we are and where we are going.

The technical sessions devoted to the surveying and mapping profession were largely confined to meetings in the Conrad Hilton Hotel on September 12 and 13. Many members of the ACSM took an active part and presented papers at the technical sessions of the Surveying and Mapping Division meetings of the American Society of Civil Engineers held on Friday, September 12.

Prof. George H. Harding, President of ACSM, presided at the luncheon sponsored by the Congress on September 12. Sol A. Bauer, Chairman of the Committee on Professional Status, presented a progress report during which he reviewed the steps leading up to the present controversy regarding the classification of surveying and mapping positions in the Federal Civil Service which previously had been classified as engineering positions, and are now included under the new Cartographic Series. In discussing this problem, Mr. Bauer pointed out the many developments in surveying and mapping techniques during the past twenty years, and the increasing complexity of these operations. New sciences are being developed and the professional status of the engineer requires re-examination in the light of these developments. The education of the surveyor in our colleges and universities to keep abreast of these demands is a responsibility that requires the attention of those engaged in the profession. A lively discussion followed the presentation of his report.

A joint session of the Property Surveys Division and the Committee on Map Use of the ACSM was held on Saturday morning, September 13. Sol A. Bauer acted as moderator during a discussion of the professional aspects of the surveyor in Illinois. Robert H. Lyddan presented a report on the "Importance of Map Use to Engineered Development" and presided during the discussion which followed.

Many surveyors practicing in the State of Illinois were present at the Chicago meeting and were interested in forming a State society. W. B. Williams, of the Michigan Society of Registered Land Surveyors, reported on the activities leading to the formation of the Michigan Society and how their program provides the surveyors of Michigan with an organization for discussion and cooperation in solving their mutual problems.

E. E. Price, Vice President of the Eugene Dietzgen Company of Chicago acted as co-chairman with the Executive Secretary, Walter S. Dix, in arranging for this ACSM meeting.

ALFRED C. STIEFEL, *Chairman*
Public Relations Committee

Fifth Annual Meeting
Virginia Association of Surveyors

The fifth annual meeting of the Virginia Association of Surveyors will be held at The Lodge in historic Williamsburg, Va. Starting with a smoker, Friday night, January 30, the meeting will be climaxed with the annual banquet and installation of officers on Saturday, January 31. Tours and other items will be included for the ladies. Thus far, items for discussion will include a presentation of various types of health insurance plans and the formation of additional chapters. Several manufacturers will, for the first time, have displays of equipment. The Association will also inaugurate a program of recognition for outstanding surveyors in the State by presenting honorary membership certificates to three men. The program limits these certificates to three men the first year and a maximum of one man each year thereafter. Worthy candidates must also be over 60 years old. Certificates will be presented at the meeting to Fred Ruediger of Accomac and J. Temple Waddill of Richmond.

In November, Joseph Berry of Vienna, Va.,

was presented an honorary membership certificate at a meeting of the Association's Northern Virginia chapter. This chapter, which included mandatory membership in the American Congress on Surveying and Mapping in its constitution, will hold its first annual meeting on February 19 in Alexandria, Va. Its members are already planning large representation at the annual Congress meeting in March.

—VICTOR H. GHENT

Personals

C. A. Wooldridge, Jr., author of the article elsewhere in this issue entitled "Real Property Surveys Based on the California Coordinate System," has recently been elected editor representative for the newly organized Northern California Section of ACSM. Mr. Wooldridge served during 1952 as a director of the local section and as chairman of its Property Surveys Division.

After serving 8 months as acting president, G. Brooks Earnest, one of the charter members of the American Congress on Surveying and Mapping, was recently elected to the presidency of Fenn College.

He is a Vice President of the American Society of Civil Engineers, and has served as President of the Cleveland chapter of this group, as well as the Cleveland Society of Professional Engineers. In 1946 he headed the Technical Societies Council, and is active in many other local, State and national organizations, including the Society of Engineering Education, the Society of American Military Engineers, and the American Society of Photogrammetry.

Professor Earnest was graduated from Case in 1927 and received his master's degree there in 1933. He was an engineering instructor at Case for 20 years and joined Fenn as Dean of Engineering in 1951. He was appointed Acting President last February.

Inauguration ceremonies will be held in the spring.

Benjamin E. Beavin, consulting engineer of Baltimore, Md., and Vice President of ACSM for 1953, was elected to membership on the Executive Committee of the Surveying and Mapping Division of the American Society of Civil Engineers on September 11, 1952, at the Chicago meeting of the Society.

Capt. H. W. Hemple, Chairman of the Control Surveys Division of ACSM from 1947 to 1949, retired from active duty with the U. S. Coast and Geodetic Survey on October 31, 1952, after serving more than 35 years with the Bureau, the last 7 years as Chief, Division of Geodesy. He was succeeded in this position by Capt. Albert J Hoskinson.

The Congress notes with regret the death, on July 4, 1952, of John E. McCarty, a surveyor in Mountain View, Calif., and a member of ACSM. Our sympathies are extended to the bereaved family.

Reprints of Articles

As a new service for members of the Congress who cannot usually know of articles prior to publication, an opportunity is now offered to obtain reprints of any article in bulk quantities. Orders must be placed with the Editor-in-Chief not later than 3 weeks after the publication date of the issue in which the article appears.

Authors of articles who wish reprints of their articles are requested to so specify at the time their manuscripts are submitted. The minimum reprint order is 50 copies.

NEW MEMBERS

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REPUBLIC SURVEYING SCHOOL, 424 Estero Cegado St., Santa Cruz, Manila, P. I.

New Map of New York State

The Department of Commerce of the State of New York recently published a new official map of the state at the scale of 1: 750,000, in seven colors. The map was produced mainly for use by the Department of Commerce of New York as a base for studies of natural and economic resources in connection with industrial location work. Industrial, commercial, educational, business, and government interests will be able to use this new base map to advantage in superimposing data essential to special studies.

The over-all size of the map is 45 by 35 inches. Coverage extends from Worcester, Mass., and the western part of Rhode Island on the east, to a point west of Youngstown, Ohio, on the west; and from Pittsburgh, Pa., on the south to Montreal, Canada, on the north.—*The Military Engineer,* July–August 1952.

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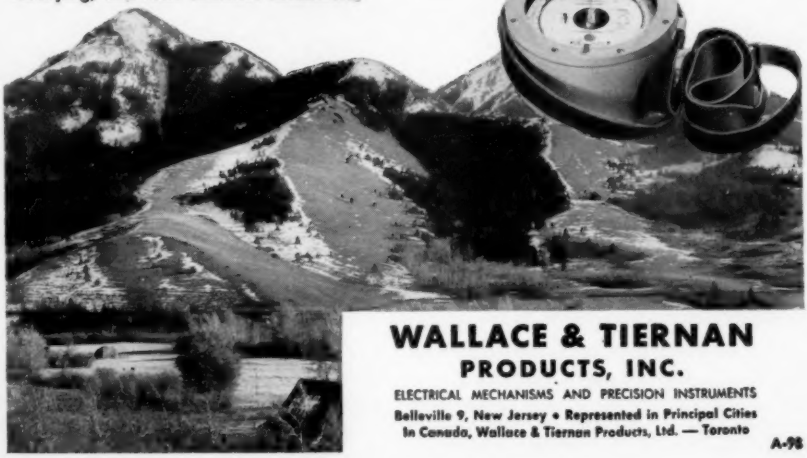

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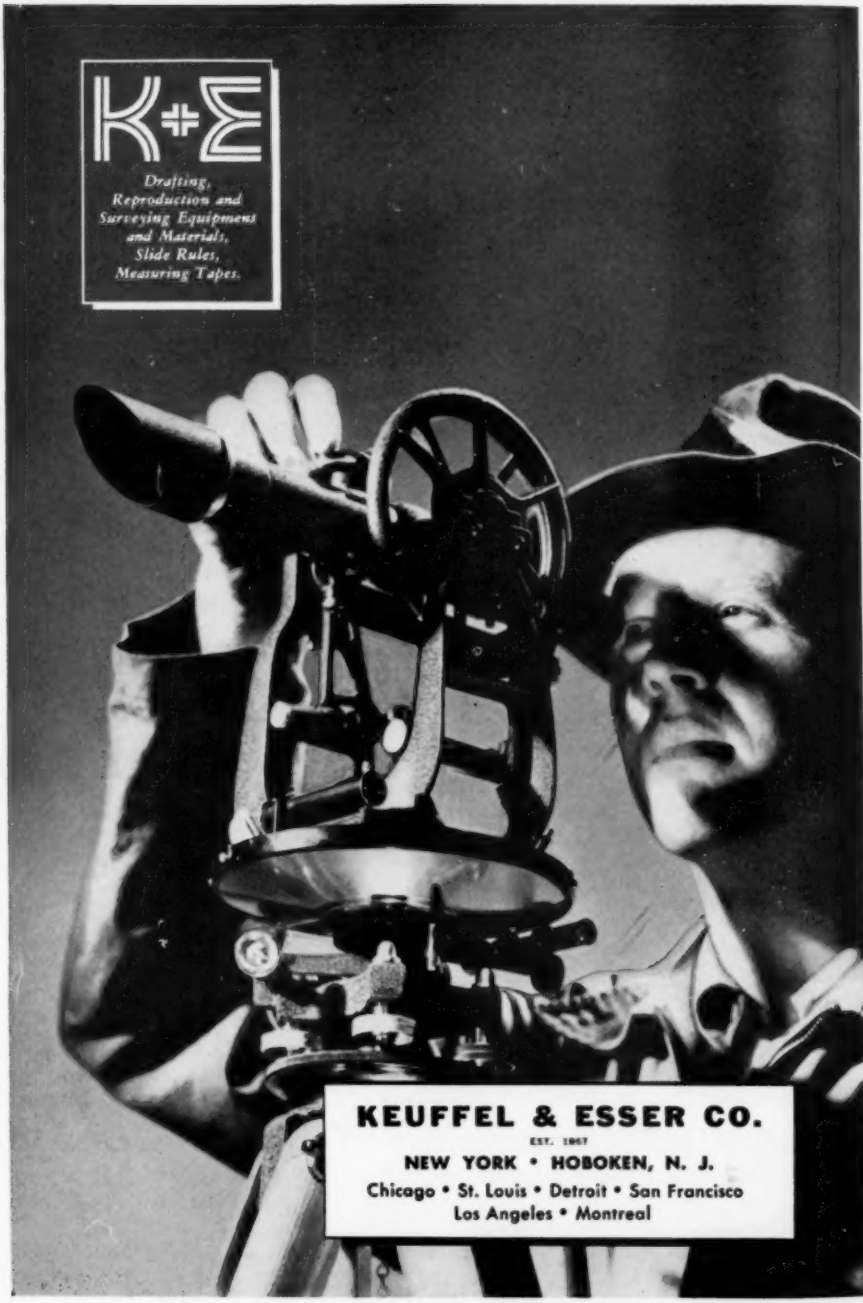
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